



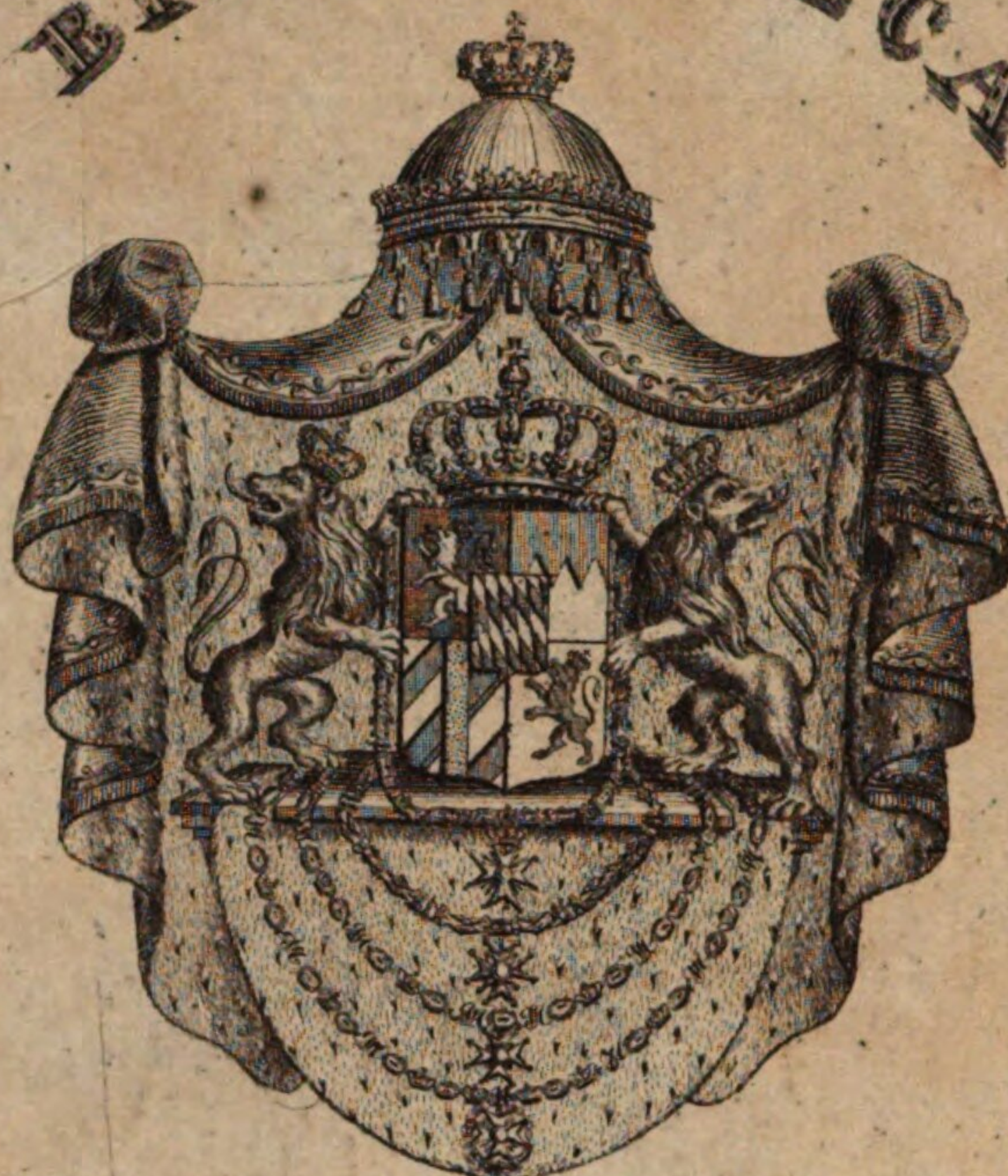


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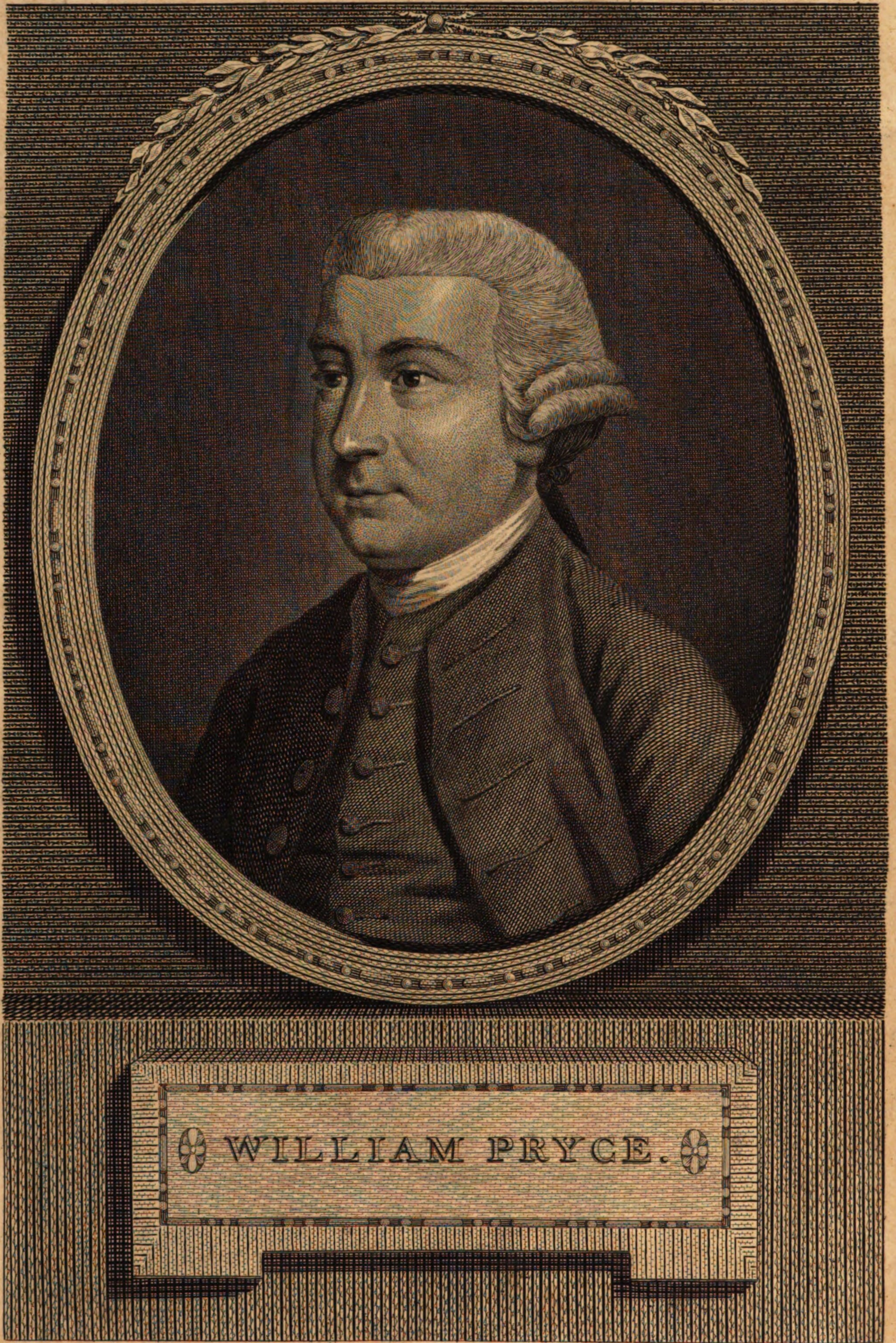












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*Effodiunt STANNUM, &c.*

DIOD. SICUL. Latin Translat.

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AND  
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BY HIS ROYAL HIGHNESS'S  
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## P R E F A C E.

**T**H E practical part of the following work was gradually collected when the writer was very young; and what was begun to be written in detached sheets, afterwards became the materials of an interesting treatise. This part, indeed, may justly be deemed the most valuable of the whole, as it tends to inform the publick of matters very little understood or considered beyond the confines of a Mineral district.

Minerals that are plenty and precious being generally confined to small tracts of country and a barren soil, are therefore remote from that publick observation which commerce and agriculture so deservedly attract: yet it is a matter of astonishment, that an object of the first national consequence, in point of time, should so long remain, even to the present hour, a secret limited to a few illiterate people. It is well known, that Tin and Lead were the first and grandest staples of Great-Britain, particularly the former, which introduced a trade and navigation before unknown to the discoverers of our western coasts. This trade founded on Mining still subsists, with many practical improvements and discoveries; and though corn and wool have contributed the largest share of riches and population to these flourishing kingdoms, yet that consideration does not by any means lessen the importance of the Mining interest. When we reflect upon the vast profusion of Silver, Tin, Copper, Lead, Iron, and Coal, yearly produced from the bowels of our Mines, which exceedingly surpasses our internal consumption, and therefore must afford a very considerable branch of commerce; we shall find it difficult to account for that supineness, which has hitherto declined the investigation of a subject of so much national importance.

The want of such assistance, in the direction of the useful art of Mining, as it is hoped this treatise may afford, has been long complained of. It cannot, however, be denied that



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our Mines are mostly well conducted; yet no small advantages may be derived from reducing the vague practice of common Miners to a regular science, and bringing the experience of many into a single point of view. Nor will those advantages be confined solely to practical Miners: every corner of this island, Ireland, and many of the colonies, abounds with a variety of Minerals, wholly unknown to the possessors; and was the knowledge of the indications of Metals, and the mode of working Mines more diffused, new discoveries would daily be made to the great profit of landed proprietors, and the advantage of the publick, by increasing its revenue, and employing considerable numbers of the laborious poor. As a striking proof of the want of such a treatise, before the latter end of the last century, vast quantities of rich Copper Ore in Cornwall were thrown away as useless! Indeed, it may be safely said, that eleven-twelfths of his Majesty's subjects are totally unacquainted with any part or branch of our enquiry, that by itself, and its great consumption of various materials, brings in so great a revenue to the crown, and so much wealth to the community.

To acquire a competent knowledge in Mines, &c. a long residence in their vicinity is certainly necessary; and this advantage, at least, I can with truth lay claim to: yet as this is the writer's first attempt in literary composition, it will, for that reason, have many faults; and he must rely on the candour of the publick for the favourable reception of an undertaking that ought long ago to have employed the ablest hand. However, I have not omitted to take the opinions of many persons well versed in the various departments of this work, which, from the number of natural and practical discoveries it contains, and the vast importance of the general subject, I may venture to pronounce, with all its faults, a valuable acquisition to the library of every nobleman and gentleman in these kingdoms.

The great parts of this work are arranged in the following order. The first book treats of the origin, formation, and substance of Minerals and Metals; the first and second chapters of which inculcate the doctrine of water, as the solvent, vehicle, and cement of Metals and Minerals, or their principles, in proportion to the saturation of the one, and the magnetism of the respective niduses of the other. The theory here given, is, in some instances, established in the process of precipitation. The third chapter, which treats of the substances of Minerals, Metals, and



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and Salts, is dry and tedious ; but as it was thought a necessary addition to the preceding chapters, it could not be omitted. With respect to the nature and history of Minerals, I confine myself to those of Cornwall only ; and as they occur in the course of my work, have described each in its incidental place. My readers will easily perceive, that if I had systematically observed those rules of genera, class, and order, laid down by Hill, Da Costa, Cronstedt, and others, I should have spun out my treatise in a needless detail of matters foreign to the professed subject of it.

The second book treats of the theory and natural history of Strata, Fissures, and Lodes, with respect to their formation, direction, inclination, interruption, elevation, and depression. The theory advanced in the first and third chapters was adopted by the reverend Dr. Borlase, and as it has been well received by the criticks of his time, it is hoped that it may still pass till a better can be found : and after all the opinions of the several naturalists are collated, and the most probable are selected, the matter will still remain a meer postulatum ; so that we would presume to judge of these only from their visible effects in the Mines of Cornwall. The second chapter contains little or no theory, being only a natural history of the contents of Lodes, according to their outward appearance ; and any person a little conversant with Mineral Ores, may form a tolerable judgment of their contents from the description here given of them.

The third book contains the practical part of Mining ; the methods of discovering and working Mines, the particular process for digging and raising of Ores, and the machinery for drawing water. Though in this part the reader may find a fund of information that he has never seen opened before ; yet it can be considered only as a summary of Mining, it being endless to enter into all its different modifications. The first chapter treats of the discovery of Mines by the Virgula, Shoding, and Costeaning, especially the former ; and gives an improved idea of a science in discovering Mines very little understood out of Cornwall. The merit of the essay on the Virgula Divinatoria is due to Mr. William Cookworthy, of Plymouth ; and though the virtues of the rod may not be easily allowed by the incredulous, yet for my own part, I want no further evidence of its properties than I have already obtained to fix my opinion of its virtues. At least, the memoir is curious, and the subject deserves to be further enquired into. In the method of Shoding,  
I have



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I have been more full than any preceding writer ; and, I hope, with a judgment that will rescue this science from the darkness with which it was enveloped. The second chapter contains an account of the methods of Streaming in its present improved state. This immediately follows the chapter on Shoding, because of its near affinity to that subject. The practical part of Shoding and Streaming is founded upon a belief of the Noachian deluge and its effects, which are incontestably verified in Shode and Stream works. In the third chapter, the effectual working of a Mine is exhibited in the sinking of Shafts, driving Adits, digging and raising of Ores, drawing the water, and every other operation under-ground. This is intended to explain the several parts of a Mine, and their dependency on each other ; and to evince that such contingencies must be in all Mines, although varied in their situations according to the different circumstances of different Mines. To this is added, a parallel section of the greatest Mine now at work in Cornwall, to illustrate the whole. The chapter following relates to the management of a Mine when in a proper course of working ; wherein such maxims are laid down, that a novice in conducting a Mine may understand some matters indispensably connected with that art. The last chapter of this book treats of Damps, Dialling, and Levelling, with practical instances and remarks, supported by experience, and altogether necessary.

The fourth book treats of the several manuductions used in dressing of Tin, Copper, and Lead Ores, and contains some brief remarks upon dressing Gold, Silver, &c. Though the general manner of dressing Copper Ore was first taken from the methods used in the Lead Mines, yet there are so great a variety of Copper Ores requiring very opposite treatment in their dressing, that I hope the subject will be found greatly improved. The dressing of Tin is indeed an art confined to the stannaries only ; yet the curious delicate manner in which it is manufactured in the dressing, may furnish many improvable and beneficial hints for the cleansing of other Minerals from their fordes. I have been very accurate in describing the manner of dressing Tin Ore, as I have had ample experience in that business ; and I doubt not of its proving a useful and general standard in that branch of Mineralogy.

The beginning of the fifth book consists of a memoir upon assaying, and more particularly upon a part of the Docimastick art, which has never been so experimentally treated of before,  
viz,



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viz. How to assay Mundicks and Tin for Gold or Silver ; by which processes the curious may judge how far the Mundicks of one place are superior to those of another for the precious Metals, or whether they contain any Silver or Gold. The processes for assaying Copper Ores by calcination, and by the regule way, are both infallible, if the operator will be attentive to his business. These processes are little known out of the Cornish assay offices, and have been too long kept profoundly secret, for purposes which the reader will readily comprehend. The method of assaying Tin Ore is very simple and efficacious, from the easy fusibility of its Metal. An adept in trying Copper Ores will soon know how to manage in assaying Cobalt, by the mode presented to his view in this chapter.

The last and grand object, is the manufactory of Tin and Copper Ores into their respective Metals ; and I have set forth, as succinctly and clearly as the materials I have obtained would allow, the processes of smelting and metallizing those products, without infringing too much upon the secrets of private trade. And though I have not forgotten to point out the oppressions of monopoly, yet it is with less severity than is due to the magnitude of the evil, and its mischievous effects.

The Appendix treats of the great improvement in the steam fire engine by Mr. Watt ; an invention of more consequence to the Mining interest of Great-Britain, than any discovery that has been made for half a century ; and I hope to see its universal use established in a very short time.

As the idioms and terms of Cornish Miners are mostly derived from the ancient Cornish British dialect, and therefore not easily intelligible to gentlemen unaccustomed to Mining, who may have occasion to converse or correspond with them ; to prevent misconception, I have subjoined an explanation of those terms in alphabetical order, including the relation they bear to those of the Lead Mines and Collieries.



view how to assay Minerals and Tin for Gold or Silver; by which process the curious may judge how far the Minerals of one place are superior to those of another for the purposes of assaying, or whether they contain any Silver or Gold. The process for assaying Copper Ore by calcination, and by the retort way, are both infallible, if the operator will be attentive to his business. These processes are little known out of the Cornish assay office, and have been too long kept practically secret, for purposes which the reader will readily comprehend. The method of assaying Tin Ore is very simple and efficient, and from the early facility of its Metal. An adept in assaying Copper Ore will soon know how to manage in assaying Cobalt, by the mode patented to his view in this chapter.

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INTRO-



## INTRODUCTION.

**A**S all ages from the foundation of the world, have been productive of continual improvements, and different modifications of matter; so likewise every kingdom and province, has experienced the vicissitude of time and things, and that rotation to which all matter is liable. However, amidst all the changes of sublunary affairs, each country respectively has been ever remarkable for its peculiar produce, trade, and commerce; and we may suppose from the nature of particular things, which are solid and durable, that the constituent principles of Minerals and Metals, although subject to a degree of fluctuation common to the mundane system, have undergone the least variety of any matter. Hence it is we find, that most countries, which have been remarkable, time out of mind, for supplying the world with certain Minerals and Metals, respectively maintain to this day a superiority for their singular products.

Among such, the ancient kingdom of DUNMONIUM, which signifies Hills of Tin Mines, and takes its name from thence, may with great propriety claim a distinction in the annals of Metallurgy; but more eminently ought that part of it called Cornwall to be distinguished, as having, perhaps, yielded more Tin in one year, than Devonshire has done in half a century. I may yet proceed, and infer, how super-eminently this little province of Great-Britain deserves to be ranked amongst the first principles of this island, as a nation and people, whose very name, according to the ancient authority of Bochart, and the later opinion of Boerhave, is derived from Bratanack, which, in the Phenician language, signifies The Land of Tin.

Tyre and Sidon were situate in Phenicia, a part of the ancient Palestine; and were the first maritime powers that we read of, either in sacred or profane history. Tyre (the grand sea-port and mart of Phenicia) was taken and entirely demolished by Nebuchadnezzar, in the thirty-second year of his reign, and in the year 573 before Christ; so that the latest date of their trading here, cannot be less than four and twenty centuries



since. I believe it is agreed by all writers, that they were the first who used to frequent this island for commerce; that they traded upon the western coasts of Cornwall, full six hundred years before the coming of our Saviour; and that their navigation to it, was for the sake of our Tin. They considered this traffick as a point of such consequence, that they erected forts and castles on our coasts for the protection and preservation of their commerce; and a great number of the proper names of men and places in Cornwall, are plainly derived from the Syriac tongue.

The learned doctor Borlase inclines to an etymology from a Hebrew root, whose termination Tania of Grecian extraction, gives another idea of the name in question: but if we admit the Phenician language to be immediately derived from her neighbour, and the mother of tongues, we may incline very easily to consider our county, as the parent of one general name for the whole island; and that the antiquity of our Tin trade has been established upon mercantile principles, for at least two thousand four hundred years past.

I hope the reader will not judge it improbable, if we suppose that the first inhabitants of Cornwall and Devon, after the flood, were well acquainted with Tin in its richest Mineral state; for it requires no uncommon degree of intellectual examination to comprehend, that, in the earliest ages from that grand epocha, our richest shode and stream Tin must have been found plentifully disseminated upon the surface of our vallies, and the sides of our hills and mountains. Those fragments and nodules, by their colour, shape, and gravity, must have attracted the notice and consideration of the first natives, if they did not allure the attention of those immediate emigrants who were “scattered  
“over the face of the earth, when the sons of men multiplied  
“in the land.” We have, therefore, much plausibility on our side to conjecture, that Tin was known as a Metal among our progenitors, so long as four and thirty centuries ago.

They could not observe the singular shape and weight of shode and stream Tin, without considering the contents as a Mineral, which by its superior gravity would afford some metalline substance; especially, when by a comparison with the Mineral Ores of other Metals, known long before the flood, they must have had all the reason in the world to conclude upon its metalline consistence. Information, or perhaps experience  
in



in the methods of extracting Metal from other Minerals, must have directed them in what manner to purge our Metal from its native dross. The richness of the Mineral, and its natural easy fluxility in the fire, soon confirmed their conjectures; and the beautiful colour, and innocent properties of the Metal, no doubt rendered it as valuable in their estimation as Silver and Gold; until, by great abundance, which renders all things cheap, it sunk in the scale of comparative excellence with those Metals.

Tin, in its Mineral state, being totally unknown to all other countries but our own, affords ample reason to assert, that we supplied all the markets of Europe and Asia with that commodity in early ages. Accordingly, we read of Tin in Judah so long back as the reigns of Uzziah, Jotham, Ahaz, and Hezekiah; (Isa. i. 25.) and also in the writings of Homer, who flourished 907 years before Christ:

“ In hissing flames, huge Silver bars are roll’d,  
 “ And stubborn Brass, and Tin, and solid Gold.  
 “ A darker Metal mixt intrench’d the place,  
 “ And pales of glittering Tin th’ enclosure grace.”

Pope’s Hom. Iliad, L. 18.

From hence we would infer, that all Tin produced in the primitive ages of the post-diluvian world, was from stream or shode; perhaps many ages before deep Mining was at all known. We have authority to say, from Mr. Carew, and a M. S. of Serjeant Maynard, which we have seen, that the working of Lodes was unknown to our ancestors in the first ten centuries after the incarnation; so that we may reasonably conclude, our Lode or Mine works are not of 700 years standing.

It has been hitherto an object of enquiry, from whence our Tin was shipped in the time of the Phenicians: some say, from the Cassiterides or Scilly Islands; Bolerium, or the Land’s-End; others say, from St. Michael’s Mount; and others, from Ostium Kenionis Valubia, or Falmouth.

The ignorance of true geography and navigation in the times of Timæus, Strabo, Diodorus Siculus, Polybius, and all the ancient historians and geographers, was so great, and their descriptions so obscure and contradictory, that it may ever remain a matter of conjecture and controversy, whence our Tin was exported for  
 Phenicia



Phenicia or Rome, by the records they have left behind them. It seems probable, that they included the promontory of Bolesium among the Cassiterides, and denominated all the south-western coast of Cornwall as part of them; which being the first land discovered by the navigators of those days, gave one general appellation to the whole.

The vestigia of any Tin Lodes, Mines, or workings, in the islands of Scilly, are insufficient to convince us, that they only gave this beautiful Metal to the world: the remains of any such workings are scarcely discernible; for there is but one place, that exhibits even an imperfect appearance of a Mine; and so necessary an appendage to a Mine as an adit to unwater the workings, is not to be seen in all the islands. If, in those days, the Metal was produced from stream or shode stones only, we must undoubtedly have discovered, in latter times, those Lodes or veins from whence they were dismembered by the deluge. They must have been wrought for Tin since the earlier ages; and some remains of such Lodes would now be visible on the sea coast or cliffs, if many such had ever been: we are, therefore, strongly induced to believe, that the Mineral Ore of Tin was anciently procured within the four western hundreds of Cornwall, and there smelted into white Tin, by charcoal fires, as the want of a proper bitumen in those days, and the entire demolition of all the woods near the Tin Mines, very plainly evince.

Besides, unless we make great allowances indeed for encroachments of the ocean since those early ages, the islands of Scilly are merely in their present state a cluster of barren rocks, the principal of them measuring but three miles long and two wide. Whence should all this Tin arise? Likewise the state of population then could not admit of emigrations from the insular continent for digging, raising, and smelting a Metal, which the mother island produced in such vast profusion from her own bowels.

Without partiality to any particular opinion, we must own the harbour of Falmouth seems to us the most commodious, both for natives and foreigners, to have carried on the business for exportation of this grand monopoly, which supplied all the Mediterranean markets: and we are not singular in this thought, but are very plausibly supported by a learned collator of our own country, in whose MS. we find an ingenious  
etymology



etymology and topographical agreement in relation to the matter before us. (Hals).

“ This harbour of Falmouth has been famous over Europe and Asia ever since the island was first known, though but darkly distinguished by the Greeks and Romans under several appellations; for instance, by one (in Greek) The Mouth of the Dunmonii Island: for neither Greeks nor Romans knew whether this province of the Dunmonii was an island of itself, or part of the insular continent of Britain, till the time of the Roman emperor Domitian, when he circumnavigated the whole island with his fleet. Besides, it was the custom of the Jews and Greeks, to call remote and strange lands, Islands, and the natives, Islanders: to which purpose we read, Isaiah lxvi. 19. “ Tubal, Javan, and the isles afar off,” which were the continent of Greece and Spain.” Also, Genesis x. 5. and elsewhere, by the name of the isles are meant the islands, and in general all the provinces of Europe. And it is observable, that where the prophet Isaiah foretels the calling of the Gentiles, he makes particular mention of the islands, (chap. xli. xlii. xlix. li. lx.) which many interpreters have looked upon as a plain intimation, that the Christian religion should take deepest root in those parts of the world, which were separated from the Jews by the sea, and peopled by the posterity of Japhet, who settled themselves in the islands of the Gentiles. So that the islands, in the prophetic stile, seem particularly to denote the western parts of the world, the west being often called the sea in scripture language. But to proceed:

“ Strabo calls this mouth of the Vale river, Ostium Kenionis, and more properly Valuba, or Valubia; that is, the wall, defence, point, or promontory, of the said Vale, now St. Anthony's Point; or Val-Ubii, from the colony of the Ubii, a people of Belgia, who planted themselves on the Vale river before Cæsar's days. (From which Ubii, might come Cornubi-ensis.) Further, Diodorus Siculus tells us, that all Tin was fetched out of Britain: as it is in some authors, after the Greek version, from Νῆσος Ἰκτα, Κι Οκτα (Nesos Ikta, Ki Oкта) which seems to say in British, first, the Good Lake, or Haven Island, and the second (what we now call Bud-Ok) a Bay of Oak Island; and, indeed, the memory of such Ike seems yet preserved in the present names of Car-ike road, the chief part of Falmouth harbour, from whence, to this day, the major part of our Tin is still exported; and Arwynike, and Bud-ike lands, by which  
c the



the said harbour is bounded. Now, this word Ike, I am informed, is derived from the same Japhetical origin as the Greek *ἵκω*, (Eko) venio, to come, arrive at, or enter into a place; and, therefore, as aforesaid, in Cornish British, it means not only a haven of the sea for traffick, but a place where a river of water hath its current into the sea; from whence, perhaps, the Latins had their Ictus, to signify the course of a river. And from this etymology we may the better understand the words of Diodorus Siculus, from the Greek rendered into Latin, thus:

“ Britanni, qui juxta Valerium Promontorium, incolunt, mercatoribus, qui eò Stanni gratia navigant, humaniores reliquis erga hospites habentur. Hi ex terrâ faxosâ, cujus venas sequuti, effodiunt stannum; quod, per ignem eductum, in quandam insulam ferunt Britannicorum juxta, quam Ictam vocant.”

“ The Island which he calls Ictam or Icta, adjoining thus with Britain, is certainly that which is now called the Black Rock Island in Car-ike road aforesaid; which, as he said, was then an island at flood or full sea, though at low water passable from the main land. There is also a Cornish MS. of the Creation of the World, a Play, brought into Oxford in 1450, and which is still extant in the Bodleian library there; which will at the same time serve to evince, that the now Black Rock of Falmouth was in old time the Island, the Ikta of Diodorus Siculus, from which Tin was transported into Gallia: a few words of it therefore here follow faithfully transcribed, with their translation: they being spoken as by Solomon, rewarding the builders of the universe (a very great absurdity in the poet) page 151; which was then, perhaps, a true description thereof:

|                             |                                  |
|-----------------------------|----------------------------------|
| “ Banneth an tas wor why;   | Blessing of the Father on you;   |
| “ Why fyth vea gwyr gobery. | You shall have your reward.      |
| “ Whyr gober eredye         | Your wages is prepared           |
| “ Warbarth gans ol gweel    | Together with all the fields of  |
| “ Bohellan                  | Bohellan                         |
| “ Hag goad Penrin entien    | And the wood of Penryn entirely, |
| “ An Ennis, hag Arwinick,   | The Island, and Arwinick,        |
| “ Tregimber, hag Kegillick. | Tregember, and Kegillick.        |
| “ Anthotho gurry the why    | Of them make you a deed or       |
| chauter.”                   | charter.                         |

Leland



Leland the elder, in his Itinerary, tells us, that this river was encompassed about with the loftiest woods, oaks, and timber trees, that this kingdom afforded, temp. Hen. VII, and was therefore, by the Britons, called Cassi-tir, and Cassi-ter; that is to say, Woodland. From which place and haven, the Greeks fetching Tin, called it and the Island, so often here mentioned, in their language, Cassiteros. In further praise of which famous port, may the reader accept the following lines:

In the calm south Valubia's harbour stands,  
Where Vale with sea doth join its purer hands;  
'Twixt which, to ships commodious port is shown,  
That makes the riches of the world its own.  
Ike-ta, and Vale, the Britons chieftest pride, }  
Glory of them, and all the world beside, }  
In sending round the treasures of its tide. }  
Greeks and Phenicians here of old have been; }  
Fetching from hence, furs, hides, pure corn, and Tin, }  
Before great Cæsar fought Cassibelyn."

Hals's Paroch. Hist.

We may, hence, conclude it very probable, that this part of Great-Britain, was the first resorted to by the most ancient maritime powers in Europe and Asia, on account of its valuable, beautiful, and precious Metal; and therefore gave a name to the whole island, which, with some little variation, it retains to this day, and proves the antiquity, locality,\* and superiority of our product, and its universal supply for the use of mankind.

Such an abundance of Copper Ore, which the Mines produce at this time in Cornwall, is a clear evidence of the fertility of our county in that Metal, preferable perhaps to all the rest of England for quantity, quality, and employment. Former times might have been equally celebrated for our production of this Metal with that of Tin, had its proximity to the surface been so great: but this rich and useful Metal is placed by divine appointment more remote from the reach of human industry; and so deeply concreted in the bowels of the earth, as to elude the search of man, without the help of mechanicks and philosophy:

\* Tin is a Metal become very necessary in common life, and yet in some measure the rarest of all others. There are but few Tin Mines in Germany; nay, in respect of other Metals, few in Europe. All in Germany, as far as I know, are those in Misnia, Bohemia, and Carinthia; and formerly in Fitchelberg at Wonsiedel. Whole kingdoms, as Sweden, Denmark, Norway, &c. have no such Mines, but are supplied with Tin from England. Auth. Preface to Henckell's Pyritologia.



no wonder, then, we are not renowned for discoveries of this Metal in the distant ages of antiquity. When arts and sciences were in their infancy, it was impossible to lay open the deep treasures of the terrene system. Men, money, and materials, in former times, were more scarce: and the increase of population and specie in latter days, have progressively and mutually operated, to lay open and discover the deep recesses of the earth, and the hidden treasures of the stupendous contrivance in the matter and formation of our globe.

The superficial site of one Metal, and the central tendency of the other, give us different ideas how they are to be searched after and wrought; and those ideas can no way concatenate, but wherein those Metals may be discovered, *cæteris paribus*, equally central or superficial.

It is very seldom that Tin continues rich and worth the working, beyond fifty fathoms deep; and it is absolutely certain, that Copper is not often wrought in great abundance, till past that depth, to an hundred fathoms or more. It is also a fact, that most Mines with us, both of Tin and Copper, being richer in quality near the surface, and by that circumstance attended with less expence in the working, do for the most part reward the adventurers with very ample gain.

It should, therefore, seem eligible to bestow our attention on those skin-deep adventures, preferably to the deep Mines; but this is by no means the case in practical Mining: for, if a Mine, when she is first discovered, throws up a large profit to the adventurers, and fails soon after to their loss and detriment; they nevertheless pursue their object, under the most unpromising circumstances, with unremitting ardour, patience, industry, and resolution, scarcely parallel in any other unfortunate undertaking under the sun. Every little stone of Ore brings along with it new hopes, and fresh vigour. It fans the glimmering flame of adventure, which had been kindled before by the fire of a certain Provincial Spirit, that seems to animate the natives of Cornwall, and to deserve that success which they cannot always command.

Neither is it wise to rely on the success of shallow Mines, though their profits may be sudden; or to desert them because their depth may prove unfavourable for some time after; for it is experimentally true, that most Mines of considerable depth, though



though vastly expensive, and the Mineral of less intrinsic worth, do, in their superlative quantity, certainty, and steadiness, make complete and substantial amends for the great labour, and persevering assiduity of their proprietors. In support of which I may venture to affirm, that six Mines produce six parts in eight of all the Copper Ore of the county at this time.

Tin in its metallick state, being to Copper but as sixty to a hundred, is notwithstanding more rich in its minerallick Ore than Copper, as it comes from the Mine; therefore they require different management in the dressing, and cleansing them for the furnace. The former from the smallness of its particles, and extreme hardness of the stone in which it is frequently found, requires to be triturated or pulverized as small as the finest sand, to go through repeated ablutions, calcinations, &c. and be taken up with the utmost nicety and precision; which renders it of less nett value to the Miner on account of so much trouble and expence in the minerallick manufactory thereof: but as it affords so considerable an employment for the children of poor labourers, from six years old and upwards, they are generally engaged in that branch before they commence underground Tinnners, and from the age of puberty are indiscriminately denominated Tinnners by that means.

Among the working Tinnners, this darling Metal holds her empire in the heart; probably because of its locality, and the privileges, immunities, and stannary laws, whereby they are distinguished, supported, and protected, as a separate body of people.

Copper, as I have before said, being placed in the more interior strata of the earth, requires great skill in hydraulicks, and mechanicks. The appropriate qualities, gravitation, and density of the elements, ought to be nicely weighed in the scale of sound judgment. The expence of coal, candles, timber, leather, ropes, gunpowder, and various other materials, added to the labour of men, women, children, and horses, occasion such a vast monthly charge, as will not easily be credited by those who are unacquainted with Mining. It is well known, however, that some Copper Mines now extant, have each supported, for several years past, a monthly expence of two thousand five hundred pounds, including the land owner's share, which is generally a sixth, seventh, or eighth part, in specie, of the whole proceeds.



From a comparative view of the charges in working of Tin and Copper Mines, we may draw this corollary, viz. The former is wrought upon more dependent principles than the latter, which cannot be embowelled in great quantities, without the help of foreign auxiliaries, such as coal, and very large timber particularly. The Mining interest of Cornwall, therefore, deserves great attention from the government, the nobility and gentry of the united kingdoms, as tending to a considerable national advantage in the consumption of so many materials necessary for the conduct and maintenance of the Mines; whereby great trade is kept up, large duties to the community are paid, and a constant uniform nursery for seamen is easily and cheaply preserved, as our quota, of additional support of the trade, navigation, and security of these kingdoms.

With much satisfaction we can reflect upon the singular nature of our staple commodities, they being attainable at the certain loss of none but those who seek a recompence from the pursuit. Now in some kinds of trade and business, what is the profit in one man's hand, is frequently so much loss to some other individual, from whom it is either immediately or laterally derived. It is an axiom in trade, that "One man's loss is another man's gain;" but in the case before us, we take from no person's bag, but strive only to obtain the treasure of the deep, which in its hidden state yields neither glory to God nor service to man: "And all this out of a narrow slip of land usually of the most barren hilly kind, without distressing tillage, pasture, and the like, scarcely worth the remarking; and very far short of the improvements in rent for those lands which are in the vicinity of the Mines." (Borlase).

Mr. Scawen, of Molinek, was vice-warden of the Stannaries in Charles the second's time; and in a note of his, which the writer has seen, complains, that the Tin revenues were then small; but, in the preceding reigns of James the first, and Charles the first, the amount of Block-Tin yearly, was from fourteen hundred to sixteen hundred tons. It was also found by the last two farms in queen Anne's reign, and the beginning of George the first, that Block-Tin, one year with another, amounted to something more than sixteen hundred; so that, in the space of one hundred and ten years, its mean proportion was equal to fifteen hundred tons  $\text{per annum}$ . Since the foregoing time, we observe a gradual increase for thirty years following; for, in the year 1742, a proposal was made by the Mines Royal Company



Company in London, to raise one hundred and forty thousand pounds to encourage the Tin trade by farming that commodity for seven years at a certain price. A committee of Cornish gentlemen were appointed to consider of the proposals; and they reported, "That the quantity of Tin raised yearly in Cornwall, at an average for many years last past, hath been about two thousand one hundred tons; and resolved, that three pounds nine shillings for grain Tin, and three pounds five shillings  $\text{per}$  hundred weight for common Tin, are the lowest prices for which such Tin will be sold to the contractors, exclusive of all coinage duties and fees."

The rapid increase of the produce of our Tin Mines for the last thirty years, is scarcely credible: it is, however, a fact, that we have coined three thousand six hundred tons of Block-Tin in one year; and, for the last twenty years, the annual average has been about three thousand tons; which is double the quantity coined annually but sixty years ago, and one-third increase for the last thirty.

No less extraordinary has been the vast addition to the sales of Copper Ore within the last twenty years; especially as Mining for Copper, only commenced with the present century; the little which had been raised before, being adventitious, and accidentally met with in pursuit of Tin.

According to the following accounts, which are faithfully transcribed from the Copper Ore buyers books, we find the quantity sold, from 1726 inclusive to the end of 1735, was sixty-four thousand eight hundred tons, at an average price of seven pounds fifteen shillings and tenpence  $\text{per}$  ton, amounting to four hundred and seventy-three thousand five hundred pounds, which must have been yearly forty-seven thousand three hundred and fifty pounds. From 1736 inclusive to the end of 1745, seventy-five thousand five hundred and twenty tons of Copper Ore were sold at seven pounds eight shillings and sixpence average price, the amount five hundred and sixty thousand one hundred and six pounds in the gross, and fifty-six thousand and ten pounds yearly. From 1746 inclusive to the end of 1755, the quantity sold was ninety-eight thousand seven hundred and ninety tons at seven pounds eight shillings the ton, the amount seven hundred and thirty-one thousand four hundred and fifty-seven pounds; annually seventy-three thousand one hundred and forty-five pounds. From 1756 inclusive to the end of 1765, the



the quantum sold made one hundred and sixty-nine thousand six hundred and ninety-nine tons, at the average price of seven pounds six shillings and sixpence, amounting to the sum of one million two hundred and forty-three thousand and forty-five pounds, and one hundred and twenty-four thousand three hundred and four pounds yearly. Lastly, from 1766 to the end of the last year, two hundred and sixty-four thousand two hundred and seventy-three tons of Copper Ore were disposed of at six pounds fourteen shillings and sixpence  $\text{£}$  ton, amounting in all to one million seven hundred and seventy-eight thousand three hundred and thirty-seven pounds, which must have returned one hundred and seventy-seven thousand eight hundred and thirty-three pounds every year of the last ten.

In order to form a more comprehensive view of the progress so lately made in Mining for Copper, we have presented the reader with a comparative scale of the above Ores, &c. where he may see for himself, the advance and improvement, which have been made in the science of Metallurgy in this part of Great-Britain. And when we reflect upon those great and sudden improvements in the art of Mining, we may justly give ourselves all the merit, which we really deserve for our superior excellence to all the rest of our fellow subjects in this singular branch of knowledge. We do not know how much our gratulations may be damped, when we further observe, that (from some cause which we cannot perfectly account for at this time) the intrinsic value of our hard gotten commodities, has decreased in some ratio to the advance in quantity, which ought to be a matter of very serious enquiry with all the gentlemen of Cornwall, whom it so nearly concerns, and from whom we may expect that redress by their united efforts, which the declension of our Mine trade so greatly requires.

It is the popular opinion, that no real surplussage beyond the charges of Mining do arise to the adventurers in general; and that in Tin particularly, the credits are unequal to the outgoings. Nevertheless, we see, in our county, that many men have made opulent fortunes by their success in Mining; therefore it is difficult to account for the truth of this matter, unless we suppose the profit of the great Mines to be sunk in the unfortunate adventures, and like national lotteries, the individual profit to be taken out of the general loss. It is indubitable, however, that the publick is manifestly enriched by the great trade and circulation of money, consequential to this peculiar business.

Whether



Whether this equipose in the profit and loss, is a fact, or only a false allegation, I will not take upon me to say; but if they be not tantamount to each other, we verily believe upon the whole, the gain is far short of that recompence which is due to the resolution and sedulous pursuit of the Mine Adventurers in Cornwall.

Supposing the proceeds in Tin and Copper to be annually four hundred thousand pounds, and the separate gain being aggregate; upon a dividend of twelve and a half  $\text{p}$  cent. it will come out fifty thousand pounds, which is only a profit of one-eighth upon the certain risk of so large a sum: but those who are conversant in Mining, we are well assured, would be very happy if they could promise themselves only seven blanks to one prize, which from unlucky experience we know to be not the case, and that nineteen blanks to a prize, will more nearly quadrate with the truth of the matter, by which our former dividend is reduced to five  $\text{p}$  cent. and the gross gain to only twenty thousand pounds  $\text{p}$  annum.

This, however, makes some profit appear; but how small, if true! how inadequate to the sum laid out and expended! This shews the infatuation, and delusive hopes of political gaming, under which stigma it apparently lies. We shall forbear any further reflections upon the subject, lest we incur the blame and reproach of our neighbours and countrymen; but as we write for the publick eye, we find it necessary to relate facts as they occur, whether they are displeasing to the interested or not. In pursuance of which determination, we hope the landholders will hold us excusable, when we assert upon the clearest conviction, that they contribute by their heavy exactions to deprive the industrious adventurers of too large a proportion of that profit, which ought to be applied for the encouragement and reward of their arduous and expensive undertakings. At a medium, the Lords of the soil have one-seventh part clear from all expence: now the one-seventh of four hundred thousand pounds, being fifty-seven thousand one hundred and forty-two pounds, it appears, by a striking comparison, for whom the Mines are wrought, and who are the principal gainers thereby; and very completely accounts for the great complaisance, candour, gratitude, and generosity of those gentlemen, to the several Adventurers in their respective estates.

At



At this time, when all the necessaries of life are high in value, the price of all manner of materials advanced, the wages of labourers from a natural consequence proportionably increased, the price for Tin sunk down from three pounds ten shillings to three pounds, and Copper Ore fallen more than thirty per cent. below the true standard, have we not great reason to fear the event of such combined and adverse causes to the prosperity of this county? Is it not alarming? And how shall we account for all that supineness which is manifested by those, whose interest and business it should be to mitigate the recited distresses of a laborious and useful community?

Government would reap a very fruitful harvest annually, from a suitable encouragement of the Mining interest in Cornwall. We believe, if the managers of publick affairs would lessen some of the heavy duties upon our materials, and wholly remit others, such indulgence would operate as a bounty, and greatly multiply our contributions to the national revenue, by animating the Mine Adventurers to rework several deep expensive Mines, now dormant through the great pressure of weighty imposts, upon the back of many natural difficulties and obstructions.

The drawback upon coal used in our smelting-houses and fire engines, has been attended with such happy consequences for the publick, that we may venture to affirm, not one-fifth of the fire steam engines now working, would ever have been erected without such encouragement. Thirty-six years ago, this county had only one fire engine in it: since which time above three score have been erected, and more than half of them have been rebuilt, or enlarged in the diameter of their cylindrical dimensions.

We shall leave the publick to reflect and animadvert upon this notorious truth.



An Account of all the Copper Ores fold in Cornwall the last fifty Years ; their Tonnage, Amount, Price, and Value.

| Date         | Ten Years Tonnage | ditto Average Price & Ton | Amount    | Average Annual Tonnage | Average Annual Amount |
|--------------|-------------------|---------------------------|-----------|------------------------|-----------------------|
| 1726<br>1735 | 64,800            | £7 15 10                  | £473,500  | 6,480                  | £47,350               |
| 1736<br>1745 | 75,520            | 7 8 6                     | 560,106   | 7,552                  | 56,010                |
| 1746<br>1755 | 98,790            | 7 8 0                     | 731,457   | 9,879                  | 73,145                |
| 1756<br>1765 | 169,699           | 7 6 6                     | 1,243,045 | 16,970                 | 124,304               |
| 1766<br>1775 | 264,273           | 6 14 6                    | 1,778,337 | 26,427                 | 177,833               |

| Date | Ann. Tonnage | Date | Ann. Tonnage | Date | Ann. Tonnage |
|------|--------------|------|--------------|------|--------------|
| 1726 | 5,000 Tons   | 1743 | 7,040 Tons   | 1760 | 15,780 Tons  |
| 27   | 6,700        | 44   | 7,230        | 61   | 17,004       |
| 28   | 6,800        | 45   | 6,700        | 62   | 16,054       |
| 29   | 6,870        | 46   | 7,000        | 63   | 17,898       |
| 30   | 6,900        | 47   | 4,900        | 64   | 21,489       |
| 31   | 7,000        | 48   | 6,000        | 65   | 16,774       |
| 32   | 7,290        | 49   | 7,200        | 66   | 21,251       |
| 33   | 7,000        | 50   | 9,400        | 67   | 18,502       |
| 34   | 6,000        | 51   | 11,000       | 68   | 23,671       |
| 35   | 5,240        | 52   | 12,050       | 69   | 26,655       |
| 36   | 8,000        | 53   | 13,000       | 70   | 30,776       |
| 37   | 9,000        | 54   | 14,000       | 71   | 27,896       |
| 38   | 10,000       | 55   | 14,240       | 72   | 27,654       |
| 39   | 11,000       | 56   | 16,000       | 73   | 27,765       |
| 40   | 5,000        | 57   | 17,000       | 74   | 30,253       |
| 41   | 5,500        | 58   | 15,000       | 75   | 29,950       |
| 42   | 6,050        | 59   | 16,700       |      |              |



An Account of all the Copper Ores sold in Cornwall the last  
 six years; their Tonnage, Amount, Price and Value.

| Date | Tonnage | Price per Ton | Amount    | Average Annual Tonnage | Average Annual Amount |
|------|---------|---------------|-----------|------------------------|-----------------------|
| 1726 | 6,200   | 47 15 10      | £173,200  | 6,480                  | £173,320              |
| 1727 | 7,250   | 7 8 0         | 260,100   | 7,252                  | 260,010               |
| 1728 | 6,790   | 7 8 0         | 231,427   | 6,870                  | 231,442               |
| 1729 | 10,600  | 7 6 0         | 1,243,042 | 10,970                 | 1,243,304             |
| 1730 | 10,423  | 6 14 0        | 1,778,331 | 10,427                 | 1,778,833             |

| Date | Ann. Tonnage | Date | Ann. Tonnage |
|------|--------------|------|--------------|
| 1726 | 6,000 Tons   | 1743 | 7,040 Tons   |
| 27   | 6,700        | 44   | 7,230        |
| 28   | 6,800        | 45   | 7,500        |
| 29   | 6,870        | 46   | 7,000        |
| 30   | 6,900        | 47   | 4,900        |
| 31   | 7,000        | 48   | 6,000        |
| 32   | 7,200        | 49   | 7,200        |
| 33   | 7,000        | 50   | 9,400        |
| 34   | 6,000        | 51   | 11,000       |
| 35   | 5,240        | 52   | 12,050       |
| 36   | 8,000        | 53   | 13,000       |
| 37   | 9,000        | 54   | 14,000       |
| 38   | 10,000       | 55   | 14,240       |
| 39   | 11,000       | 56   | 16,000       |
| 40   | 5,000        | 57   | 17,000       |
| 41   | 5,200        | 58   | 15,000       |
| 42   | 6,000        | 59   | 16,700       |



## GENERAL TREATISE

UPON

## MINERALS, MINES,

## MINING.

## BOOK I.

## CHAPTER I.

## Of the Origin and Formation of Metals and Minerals.

**F**ROM the invisibility of the original causes of Minerals and Metals, every system and theory, framed to account for their production, must be speculative and controvertible. The mundane theories of Burnet, Woodward, Whiston, De la Prime, Scheuzer, and others, though they have all their probabilities, are all liable to many objections. Indeed, to search into the secret causes of several appearances in nature that are evidently existing, and obvious to our senses, both in her gross and minute operations, requires so much accurate labour, sound learning, and solid judgment, that as it would appear presumptuous in me to obtrude any particular theory of my own, I shall only offer my opinion in the following sheets, with all imaginable deference to the judgment of the candid publick.

Though the stupendous views we have of divine architecture, fill our souls with admiration and astonishment at his power who framed the heavens, and laid the foundations of



the earth; yet the minutest of his works, for their exquisite symmetry and delicacy, are equal evidences of the boundless skill of the divine Artist, who hath furnished us with no less matter of meditation and wonder in the conformation and instinct of the most contemptible insect, than in the attributed sagacity and unweildy bulk of the elephant.

Well might the immortal naturalist say, "That in nothing more is seen the workmanship of nature (God) than in the artificial composition of these little bodies," which in his contemplation on the body of a gnat he so elegantly illustrates; "Ubi visum pretendit? Ubi gustatum applicavit? Ubi oderatum inferuit? Ubi verò truculentam illam, et portione maximam vocem ingeneravit? Qui subtilitate pennas adnexuit? Prælongavit pedum crura? Disposuit jejunum caveam uti alvum? Avidam sanguinis, et potissimum humani, fitim accendit? Telum verò perfodiendo tergori quo spiculavit ingenio? Atque ut in capaci cum cerni non possit exilitas, ita reciproca geminavit arte, ut fodiendo acumina pariter forbendo que fistulosum effet." (Pliny.)

If Pliny had been acquainted with microscopick discoveries, where would he have found words to express his admiration at Dr. Hook's assertion; "That if a large grain of sand was broken into 8,000,000 of equal parts, one of them would exceed the bigness of those creatures, who were so exceeding small, that millions of millions might be contained in one drop of water!"

If we descend from the surface of the earth, we shall likewise find in her bowels endless stores of fossils, petrifications, minerals, and metals, to supply mankind with the means and materials of every ornament and conveniency: in which we may, as through a glass darkly, behold the secret operations of him that worketh all in all, both in the heart of man, and in the bowels of the earth! "Great and marvellous are thy works, O Lord God Almighty! In wisdom hast thou made them all—the earth is full of thy riches!"

It is very probable that the nature and use of Metals were not revealed to Adam in his state of innocence: the toil and labour necessary to procure and use those implements of the iron age could not be known, till they made part of the curse incurred by his fall: "In the sweat of thy face shalt thou eat



“ eat bread, till thou return unto the ground ; in sorrow shalt thou eat of it all the days of thy life.” (Genesis.) That they were very early discovered, however, is manifest from the Mosaick account of Tubal Cain, who was the first instructor of every artificer in Brass and Iron ; and being the son of Lamech, who was the father of Noah, must have been such an instructor Anno Mundi 1,200, or thereabout. Whether this is the same person as in the Heathen mythology is called Mulciber, or Vulcan, who was the god of subterranean fire, and esteemed the president over Metals, it is not essential to our purpose.

It has been long disputed whether Metals are generated, or were all originally produced at the creation : whether they admit of germination, or augmentation, like animal or vegetable bodies, or whether they proceed from an accumulation and cohesion of metallick particles ; or by what other means they were formed and produced.

The doctrine of the alchymist maintains, that they proceed from a certain Primum Ens, or first seed of Metals, which they say is a kind of moist vapour or Gas, that changes the earth and juices it meets with in a vein into a mineral body or substance ; and thence converts the Minerals into Metals or Ores by a continued fermentation and elaboration in the Mines, caused by the Archeus or heat that acts on the veins, as it proceeds from the center of the earth ; it asserts also, that different Metals are produced conformable to the time and degrees of fermentation which the Mines have undergone ; and partly by the purity and suitableness of the veins, or the earth in them, which they suppose are as matrixes to contain and nourish Metals in embryo ; so that in the space of a thousand years, it seems, a Metal is generated and perfected de novo, according to the concurrent causes, such as the impregnation of the Archeus, or the like. But this doctrine of Mineral fermentation is very properly denied to have any existence, by the accurate Boerhave, who, in his History of Fermentation, declares it to belong only to the vegetable kingdom ; for he says absolutely, “ This intestine motion can be excited in vegetables only ;” and for Minerals, he does not remember that any fermentative motion has been observed therein : so that I think we may with full propriety express what is meant in the term fermentation, by effervescence, which different admixtures of Mineral particles may momentarily excite ; and



and which really conveys a separate sense and meaning, from the true natural operation of ferments.

Others will have it, that all Metals and Minerals were at first created in the very same state and nature in which they are always found, without undergoing any kind of alteration. The most common opinion among the Miners in Cornwall is, that crude immature Minerals do nourish and feed the Ores with which they are intermixed in the Mines; and that the Minerals themselves will, in process of time, be converted into Ores productive of those Metals, to which they have the nearest affinity, and with which they have the greatest intercourse. This, however, is but the common opinion. Those of most experience seem to have a contrary notion of the matter, and yet differ among themselves. We apprehend the best and most plausible reasons that can be advanced, are those which are nearest at hand, are most obvious to our senses, and are deduced from observation and experience; and therefore, without animadverting on the different opinions abovementioned, we shall proceed to communicate our own thoughts on this controverted subject.

It is reasonable to conclude, that Metals were made and implanted in veins at or very soon after the creation of the world. Tin Ore will peculiarly evince the justness of this conclusion; for it is frequently found, in its richest and purest state, in large spots and bunches in blocks of stone of the most hardened consistence, such as Granite, Elvan, and the like, which have been above the surface ever since the first induration of solids, have experienced no revolution, nor been water-charged with metallick particles, unless from the clouds of heaven. Perhaps it has been primarily so with most other Metals, as their usefulness was discovered to man before the methods of sinking deep into their proper nidusses were at all known. In other countries, where Metals may be more generally diffused, it has probably been found as I say; and from the beginning, these metallick distributions may have experienced a decay and alteration by the action of the different elements upon them, according to their specifick induration or laxity.

I have before observed, that Metals are subject to a degree of fluctuation, in common with all matter; and that they approach to, or recede from, their ultimate period, or degree of perfection, either quicker or slower, as they are of a  
greater



greater or less solid and durable frame and constitution. In favour of this opinion, it is found, that the Ores of Copper and Lead, though rich and solid in nature, yet by a long insolation, or exposure to the sun and weather for some years, lose much of their Metal: and also, that those Mines which abound with a rich mature Copper Ore, do, near the surface, at least immediately over the body of the Ore, commonly contain a rust, tincture, or spume of Copper, resembling Verdigrease; which seems to be an Ore in a declining state, being elevated by an effervescence in the bowels of the Mine from that sulphureous body of Ore which often lies under it, and to which it did belong at first, and was united with it, till some intervening cause occasioned so visible an alteration in the Ore of one and the same Mine.

It seems to me that in every Metal there is a peculiar magnetism, and an approximation of particles sui generis, by which its component principles are drawn and united together, particularly the matters left by the decomposition of the waters passing through the contiguous earth or strata, and deposited in their proper nidus; till, by the accretion of more or less of its homogeneous particles, it may be demoninated either rich or barren.

That Ores, and even virgin Metals, are or may be formed in this manner, seems manifest from a method now in use, of extracting Copper from waters strongly impregnated therewith: Iron which has lain some time in such water, is found on examination to be greatly corroded, and to have Copper formed in its stead, either adhering to the Iron, or sunk to the bottom of the vessel, in form of rust, and sometimes even in small grains of a complete metallick appearance.

This Copper and rust on being smelted with a reducing flux, sometimes produce above three-fourths of their weight pure Metal. The water generally used for this purpose is that which is left by lotions of black Tin, intermixed with Copper, after it has been calcined in the proper furnace, commonly called a Burning-House. The Copper contained in this water, is kept in solution by an acid; and this acid having a greater affinity with Iron than with Copper, on the immersion of Iron, quits the Copper to join with the Iron; by which means a precipitation ensues, in the manner just mentioned. This process may at any time be evinced by the following experiment. Dissolve

C

thin



thin plates of Copper in Aqua-fortis, and you will have a clear liquor of a fine blue tinge: on applying to this thin plates of Iron, the acid, quitting the Copper, will precipitate it in the manner before described, as Copper would have done by Silver, had it been first dissolved in the menstruum; and as fixed alkali will do by the Iron, after it has dislodged the Copper.

From this we may reasonably infer, that water, in its passage through the earth to the principal fissures, imbibes, together with the natural acids and salts, the mineral and metallick particles, with which the different strata are impregnated; and meeting, in those fissures, matters which have nearer affinities with the acid, of course disengages it, in whole or in part, from the metallick and mineral particles, which it had held dissolved; and which, on being so disengaged, by the natural attraction between its parts, forms different ores, more or less homogeneous, and more or less rich, according to the different mixtures, which the acid had held dissolved, and the nidus in which it is deposited. The acid, now impregnated with a new matter, passes on; till meeting with some other convenient nidus, it lodges in that, and thereby acquires a fresh impregnation, perhaps at last totally unmetallick; or, for want of meeting with a proper nidus, appears at the surface, weakly or strongly tinged with those principles it had last imbibed.

By means of these acids, the Miners are often put to an extraordinary expence for Brass pumps instead of Iron; for many of the Mines have water so fully imbued with acid, that the Iron working-pieces, in which the piston of the pump works, will be entirely corroded therewith in six months; and a great expence and loss of time will be incurred, if the pumps are not previously furnished with Brass working pieces, as on them the acids, which are already saturated with kindred particles, have little effect.

These, I presume, are plain demonstrations: whence it appears, that Goffan, which is an ochreous Stone, ruddy, and crumbling like the rust of Iron, much of which it really contains, is a proper nidus for most kinds of Metals and Minerals; Iron having, even in this its mineral state, so strong an affinity with the acids, as to decompose them, when saturated with other Metals, Semi-metals, &c. on which decomposition, the precipitated matters become Ores of different kinds, and even virgin Metals, as before described.

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In Mr. Gellert's tables of affinity, Zinc is indeed placed in the first degree, and Iron in the second; but this, which refers only to their metallick state, does not affect what I have above advanced of the mineral: yet, in the mineral, Zinc is scarce ever free from Iron; the vast quantities of Black Jack which this county produces, being, by means of this mixture, rendered mostly unfit for use.

We have, indeed, several kinds of Gossans, from the different appearances of which, experienced miners form very strong and well grounded conjectures, of what they will produce when they come to be wrought: but more of this when I come to define the nature of Lodes, in respect of the earth and stones they contain.

The different alterations of substance before described, are deemed by some a genuine transmutation: but they carry the argument too far, who suppose that Minerals or Metals are entirely changed from one kind to another, as Mundick into Copper, Lead into Silver, Silver into Gold, &c. For when Metals or Ores do once arrive to their utmost perfection, which probably they were endued with from the beginning, and which is always essential to them, though subject to divers impediments and revolutions; it is not easy then to conceive, how they can by any means assume an entire alteration or renovation, so as to be transmuted from one Metal to another, by any degree of elaboration in the earth.

If this transmutation was a fact in nature, from the divers alterations which we may reasonably suppose to happen in our soluble Minerals, such as Copper Ore for instance, we might expect to meet with the most perfect Metals in our Mines; and our richest Tin Mines, by the elaboration and melioration of them in the course of two thousand years, might at this time be productive of Gold and Silver enough, to furnish a sum ten thousand times ten thousand greater than our national debt. But the wisdom of God, for the benefit of his creatures, has ordained, that things of this kind should remain enshrined in their own nature: and Tin, though united by a diffeminated quantum of Gold, will not part with its noble cement, notwithstanding the chymical analyzations of an illiterate impostor to extract a pound of Gold from every block of Tin. No, the goodness of Providence has fixed unalterable limits to the perfection of each particular Metal, to render the whole of greater service



service to mankind ; the inferior Metals, Iron especially, being of more general utility than Gold, Silver, and even precious Stones.

If it be said, that the impurities of the earth in our Mines, is the cause that nature is debilitated and frustrated in her endeavours after transmutation ; it is answered, that, notwithstanding this impediment, such a long elaboration and maturation in the earth, in so great a series of years, would necessarily and inevitably exalt the base Metals into so high a degree of purity and goodness, that they would, by this time, be greatly enriched with Gold or Silver ; and though they contain Stones and Earths of various colours and degrees of purity, yet there is no essential difference between them, from one containing a nobler Metal than another ; which would scarcely be the case, without some stronger evidence of exaltation, notwithstanding all the opposition that nature could meet with in the Mines, provided she was endued with a power of converting the base Metals into those of a superior kind.

We may likewise conclude from the premises, that the opinion of those, who hold that Metals in the earth continue in the same state as at first, is erroneous ; because the migration and egress of Metals and Minerals, is obvious enough in the investigation of Mineral Spaws or Springs.

Many of our Mines furnish Stones, perhaps of but an ounce weight, in which may be discerned the pure Ores of Tin and Copper, Copper and Lead, Zinc or Mock-lead, and Mundick, each in a separate state from the other, (by the intervention of Gossan, Cal, Flookan, Spar, and Chrystal.) How should this natural class and order of Metals, &c. be effected, but by the agency of water to bring, and the power of attraction to arrest, such and such particles, and deposit each in its proper matrix or nidus ? May we not, therefore, suppose, that Mines which are very rich at one given time and place, may in several centuries after be impoverished in that place ; and other parts of those Mines, which were then barren, may be now plentifully stored with Metal, according to the solution and transmigration of their respective principles, which are deposited in some other magnetick nidus ; whose power of retention, in process of time, may be again decayed, those principles again depart, and again be arrested ad infinitum ? This may account for the uncertain distribution of Ore, in one and the same Lode ; which may be  
very



very rich in this age, and in the following not worth any further pursuit. And this may also be the cause of the old Huel Virgin's producing near half a million sterling; and the eastern Huel Virgin's never yet producing three hundred pounds, though of seventy fathoms depth, with eight thousand pounds charge upon her, and still within forty fathoms of a gulph of Copper Ore in the same Lode.

This hypothesis, which is formed on my own observation and judgment of Metals, may not be relished by those, who have adopted the ancient opinion of the production of Metals and Minerals by vegetation; nor by those, who suppose Metals to continue always in the same state. But though I am not fond of singularity, I cannot help dissenting from the common traditions, for the reasons I have given; which, I hope, are so plain and natural, as to satisfy the reader, that there is no need of having recourse to the center of the earth for a solution of this matter. In inquiries of this nature, every one has a right to be guided by his own experience and judgment. And though the subject, at best, is so obscure and difficult, that it can never be clearly put out of dispute, yet I think, I have evidenced the proposition upon which I first sat out; namely, that all matter is subject to rotation and vicissitude, to continual different modifications, improvements, progress, decay, and reformation; and that, at the same time, the primeval principles and particles thereof remain naturally the same in some part of the universe, unless disunited by the contrivance, and for the use of man, on whom all things here below have been bountifully bestowed by him, who is the Author and Giver of all good things both in heaven and in earth.

## CHAP. II.

Of Water, the Vehicle and Cement of Metals, Minerals, Stones, &c.

**I** SHALL now endeavour to confirm what has been said, by examining what the effects are, that proceed from the causes I have supposed: and to shew the propriety of my suggestions, it will be necessary to examine into the properties of Water, as universally admitted by the most approved writers on that subject.



Next to Fire, Water is the most penetrative of all bodies; by which quality it is fitted to enter into the composition of all Animals, Vegetables, and Fossils: by this, also, joined with its smoothness, it is fitted to convey the nutritive matter of Fossils, Stones, Minerals, and Metals; passing smoothly on, it never stops the pores, but leaves room for subsequent supplies. Yet Water, which so easily separates from most bodies, firmly coheres with some, and binds them together in the most solid masses. It is by the glutinous nature of Water alone, that our houses stand: for take Water out of wood, and wood becomes rotten; out of brick, tile, and stones, and they become dust. It is evident that Water subsists in Metals; for the filings of Tin, Copper, and Lead, yield Water plentifully by distillation. "All Fossils, and even Metals themselves, are capable of dissolving in Water, and indeed are naturally mixed therewith; and this holds of all concreted saline, vitriolick, and metallick juices, of which Water makes a principal part, serving to dilute, move, change, increase, and incorporate them with each other." (Boerhaave.)

As it is evident, therefore, that the Waters flow from the circumjacent earth, or strata, into, and through the Mines, from one vein or fissure into another, and so on throughout in constant circulation, till they are discharged upon the surface, for their ultimate conveyance into the sea; so they serve as a vehicle to protrude and convey the acids, salts, and minute loose particles of Ore or Metal they meet with, into their proper matrixes or veins, where they are deposited by the decomposition of the acid, and attracted by the Metals, Minerals, or Juices, to which they have the nearest affinity; and in process of time are accumulated into large heaps or quantities, while the other earthy or stony parts of the vein are carried away by the ingress and egress of the pervading waters: and thus the Ores, or Metals, are continually complicated, congealed, and cemented, by the decomposing and magnetick quality in the Mines; to which the agglutinating petrifying nature of the Waters, doth not a little contribute.

But if these properties in the Mines be enervated or destroyed, then their particles will be disunited and separated so small, as to render them capable of being protruded and forced away by the Waters into the contiguous strata; while the impurer parts of other places are impelled by the Waters into the Mines, where they subside or lodge, in the room of the Ores or Metals that were



were thence displaced. We are sensible that the Loadstone, which has so wonderful an attraction, may lose its virtue; and therefore it ought not to be thought strange, that Mines should be subject to the like alterations, from the intervention of accidental causes.

The consideration of the nature of mineral spaws and springs, will sensibly inform us, that there is such a continual percolation of Minerals and Metals, or their salts or principles, through the pores and channels of the earth; and the goodness and providence of God are paternally apparent in their salubrious effects upon the impaired constitutions of mankind. But there is a far greater display of his benevolence to us in particular; for this town and neighbourhood are entirely supplied with pot Water from mineral springs, and those of the most deleterious miasma: nay, for the most part, our Water for culinary uses, is taken up at the low-floven, or tail of the adit, immediately where it discharges from those Mines which are not working; and have run half a mile or more over a bed of Copper, Mundick, and every other congeries of mineral poisons. This is a fact so notorious, that I can produce many thousand attestations to confirm my assertion. To what cause shall we ascribe the salubrity of Pednandrea, and Huel-Sparnon Waters? Those Mines have been wrought at a considerable depth by the power of three fire engines, and have produced vast quantities of Tin, Copper, Mundick, and some Lead; yet, at this time, when those Mines are not working, and the Water is clear, we use it for all purposes indiscriminately, without the least tinge, or the least incrustation upon our household utensils; and in twenty-four years acquaintance with the practice of medicine, I have not met with any one patient, whose disorder I could attribute to the most trifling unwholesomeness in our Mine Waters.

If the reader will advert to the true cause of these different effects in one and the same fluid, he may find it in what has been before said; and will presently join in opinion with me, in the properties attributed to Gossan Lodes: and this will be a further demonstration of the decomposition of those Waters into their primitive purity and innocence, by contact with this ferruginous medium. Again, as a proof of a proof, several Mines, whose adits are so much deeper as to be under the Gossany bed of Ores, do produce Water fit for no use but driving mill or engine wheels. Such Water is quite noxious, and palpably vitriolick to the taste, particularly at the Mines of North-  
Downs,



Downs, Chacewater, and Huel-Virgin. I know that some may say, if this be the case, these Mines will be again renovated. Probably this, in a certain degree, will be the case: but let it be remembered, that where the nidus with the decomposing matter is taken away, the Water from the circumjacent strata, instead of percolating through the vein, falls into a congregated fluid of its own kind. Indeed, where any of the vein is left in whole, as we call it, we see no reason why it should not have the same effect there as formerly; nay, we are of opinion, that where a Mine has been wrought till the Lode has proved barren in quality, and is left off from extreme poverty, if the vein continues, and is endued with the same decomposing and attractive qualities as the part formerly wrought originally might have been, such Lode may probably be converted into Ores, by the Water now percolating through it, and saturated accordingly.

The Miners often feel a palatable difference in Water underground, at a great depth; for if they taste a clear stream of Water, as it flows down upon the walls of the Lode, it is either very cold or almost lukewarm, or insipid or sweet. In Copper Mines particularly, we sometimes find the Water full as warm as new milk in one part of the mine, while it is very cold in another; nay, in several of these, particularly in Huel-Musick and Huel-Rose, the writer has stood with one foot in the warm, and the other in the cold Water, and has divided and diverted them different ways. In the former of these Mines, the discovery of this warm Water, has always immediately preceded a considerable enlargement of the Lode, and richness of the Ore. In the latter, the cause is not so absolutely determined; as the Lode from which it is known to proceed, has not been discovered at that depth; but where it has been so, it greatly abounds with sulphureous Minerals.

On the other hand, the Water which flows through a bed of Tin, is generally very fine, soft, and insipid; especially if the Lode or strata are of the Grouan or Elvan kinds, and the Tin rich in quality and homogeneous. Our clean Pryan Tin Lodes likewise yield a soft alkalescent Water, that, I am satisfied, would be of singular service to all persons afflicted with acidities in the primæ viæ.

Springs are either temporary or perennial: some say, that they originate from vapour, rain, or dews, collected on the  
fides



sides of mountains, and are thence commissioned into the bowels of the earth, in form of springs; others, that they proceed from the deep abyss; and others, that they are filtrations from the sea, into which all the rivers run, as into the place from whence they came, per modum circulationis. For, “all the rivers run into the sea, yet the sea is not full; unto the place from whence the rivers came, thither they return again.”

The theory of Mess. Marriotte and Perault, that springs have their origin from rains, hath been examined and confuted by Mr. de la Hire. Dr. Halley's hypothesis, of their being produced by vapours, though the most popular, is in a manner overturned, in our opinion, as well as the former, by Mr. Derham's perennial spring in the parish of Upminster, and various others in different parts. Of those who have mentioned that, which we conceive to be the only true origin of perpetual springs, THE OCEAN, none have, to our knowledge, assigned the QUO MODO or proper cause; and therefore leave it undetermined, or rather give up their unsupported argument in favour of Dr. Halley's more plausible and commonly received, though more erroneous, hypothesis, of its being effected by the condensation and precipitation of vapours and dews from the tops of mountains.

The stress of our argument and the novel part of our hypothesis, is, that in the formation of perpetual springs, they not only derive their Waters from the sea, by ducts and cavities running from thence through the bowels of the earth, like veins and arteries in the human body; but that the sea itself acts like a huge forcing engine, or hydraulick machine, to force and protrude its waters from immense and unfathomable depths, through those cavities, to a considerable inland distance.

One of the hydrostatical laws of fluids, being, that their pressure is in the ratio of their perpendicular altitudes, how very great, how immense must that pressure be, in the unfathomable parts of the sea! and, indeed, in those parts, which, as Varenus affirms, have been fathomed to the depth of four miles and a half! Only conceive (if possible) a forcing engine, or the best hydraulick machine, acting with a force equal to this immense pressure, upon a body of water, in order to carry it to any distance whatever, or raise it to any conceivable height! Imagine then, with what inexpressible force the water from such a pressure, must be protruded through those cavities, ducts, and

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hollow



hollow passages, from the bottom of the sea, through the bowels of the earth, to various parts of its surface, where they discharge themselves, as through so many tubes or pipes, and form perpetual springs; some rising, either from a duct of less perpendicular depth, where the pressure is not so great, or otherwise more perpendicularly than others; consequently, in either case, at a less distance from the subaqueous mouth of the duct; whilst others, running more horizontally, or derived from a greater depth, where the pressure is proportionably stronger, or, perhaps, from the duct tending for a considerable length towards the center of the earth, are forced to a greater inland distance, in the confined tubes or veins of the earth, before they emerge to the surface, which we apprehend they do from various orifices and branches, like capillary tubes from a principal artery: the pressure of the fluid acting in this instance, as in all others; and the immensity of that pressure in the sea seeming to justify our calling it a huge forcing engine, and comparing it to an hydraulick machine, whose power we can easily conceive to be sufficient, from the convexity and globular form of the sea as well as the land, to force its Waters through the aforesaid capillary tubes to the tops of the highest mountains, even without the aid of attraction, which, not improbably, may in some cases contribute somewhat towards their ascent.

That which gave birth to our conjectures, and led us into these reflections, was the consideration of the Caspian sea, as having no visible outlet; most of whose rivers, which disgorge themselves into that grand reservoir, we conceived as deriving their origin from the sea itself, being forced, by the pressure of the atmosphere and watery fluid, through subterraneous ducts and channels to certain distances, where they emerge in springs and bubbling fountains; and increasing as they approach nearer to the sea, by the accession of other Waters from other ducts, are swollen into considerable rivers of fresh Water, affording a constant supply to keep that grand reservoir "without o'er-flowing full;" which freshness, we consider, and suppose it is generally considered, as effected by the salt water being filtrated and strained through a considerable body of earth in its passage from the sea to the fountain head. As a justification of this supposition, we beg leave to mention, the brackishness of those springs, which is frequently complained of near the sea coasts; and which is undeniably occasioned by their vicinity to the sea, whose Waters are not filtrated through a sufficient body of



of earth, totally to destroy their saltness, and render them quite fresh.

We do not, however, suppose, that all the rivers which empty themselves into the Caspian or any other sea, are always derived from that particular sea into which they return: for instance, we conceive the head of the Wolga river to be more probably derived from the Frozen-sea, to which its source is much nearer than to the Caspian-sea; and which seems even necessary, in order to supply that quantity of fluid, which must be constantly evaporating from its surface, for the supply of dews, rains, &c. for an extensively surrounding country. Again; it is probable, that the Nile takes its source from the Eastern-ocean or Red-sea, rather than from the Levant or Mediterranean into which it runs: also, that the river Amazonas, takes its rise from the Pacifick-ocean, and not from the Atlantick-ocean into which it flows: and so of various other foreign rivers, which, though they may take their origin as we have here supposed; yet we further suppose, that as they arrive nearer to their mouths, they may be and are considerably increased, and receive large additions, by the like ducts and channels, from that sea likewise into which they run.

To illustrate this hypothesis, we shall mention one instance more in our own country, of the river Tamer, which divides Devonshire from Cornwall; whose head rises, we suppose, from the Bristol-channel, within five or six miles from Hartland-point; and after running near an hundred miles due south, empties itself into the English-channel at Plymouth; whilst the river Torridge, which rises on the same common, and within the distance of a few cloth yards from the Tamer, after a course of upwards of fifty miles, discharges itself again into the Bristol-channel in Barnstaple-bay, not twenty miles N. E. from its head.

Let us adduce the rise of these two rivers, as positive proof against Dr. Halley's ingenious hypothesis. "Their heads are  
 "two perpetual springs within a few yards of each other, on the  
 "pretty level summit of a vast high common, one of the highest  
 "in all the neighbourhood; where there are no rocks or crannies  
 "for the vapours or dews to gleet down by, nor any mountains  
 "or caverns above it to collect a body of water; nor any one  
 "circumstance favourable to his hypothesis." Letter from Christopher Gullet, Esq; of Exeter.

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The Waters with which our Mines abound, are derived both from temporary and perennial fountains; and are very properly distinguished with us, by the names of Top and Bottom Water. Shallow Mines have very little Water, more than comes from the surface; and it is temporary, according as the seasons vary; so that, without a competent power to draw out the Water from the workings, the adventurers are generally obliged to stop them, or "Knock the work," as the phrase is, soon after the autumnal equinox; otherwise, which is frequently the case, they expose themselves to a great expence, disappointment, and loss.

Our very deep Mines are subject to Water from both the sources before mentioned; for in the driest seasons we know of, they have a constant stream *ab interno*, which requires much expence and address to keep under: but in the depth of winter, when all the earth is drenched as it were with moisture, we are visibly affected by the concurring streams both of Top and Bottom Water; notwithstanding all precautions are used, to take up the superficial streams, by launders or grooves cut in the walls or sides of the Lode, to convey them either into the adit or tye lift of pumps, by which the burthen is eased for the engine, and the bottoms are freed from so much Water.

The deepest of our Mines are not much affected by the influx of Top Water, before the depth of winter; as it takes till that time, to fill the interstices of the earth or strata, and protrude its redundant stream to the deep bottoms. Our most experienced Miners will say, that "A dry easterly wind raises the "springs;" but although it may appear so to our outward senses, yet a little application to the solution of this phenomenon, will shew the conclusion to be false.

During three parts in four of the year, the wind blows from the intermediate points of the west and the south; and coming over a large tract of the Atlantick-ocean, and consequently fraught with much wet, discharges its moisture, as soon as the current of air, which suspended the clouds, is diminished and broke by the cliffs and hills. It was an observation made by our Saviour, that the western winds brought rain in Judæa: Luke xii. 54. The south wind coming from the coast of Africk, had the same effect in the Adriatick: Horace Lib. i. Ode 3. The west wind is often so fierce and raging after acquiring strength in the Atlantick-ocean, that it is scarce conceivable



conceivable with what fury it attacks the coasts of Britain; and it is very well known, that it commonly blows above half the year (which was also observed by Julius Cæsar) and that very violently, especially in the autumn; whence our Michaelmas storms and rain. Philos. Trans. No. 352.

In these instances, the frequent rains are the consequences of winds, passing over a large tract of water; and this may lead us to the reason, why the winds come so much from the south-west in Cornwall, that we have known them blow from that quarter the four last months of the year, almost without intermission, attended by violent floods of rain, which took all the time before mentioned to arrive at the deep bottoms; about which season, at Christmas, or very soon after, the wind shifts to the opposite point of the compass, and generally brings along with it the little frost and cold this country is subject to; mean while, the Waters are determined to the bottoms of our deep Mines, merely by the time they have had to sink down through the earth. The impatient observer wonders at this slow descent of the Waters; and when the wind shifts to the eastward, he very injudiciously attributes the effect to a wrong cause.

We confess, the above seems to us a very natural and plain explication of the affair; but as we have not that deference for our own opinion, as always to prefer it to others, we are ready to acknowledge ourselves open to conviction, if a better reason shall be advanced at any future time. And as a hint to our readers, we desire they will consider, how far the density and consequential pressure of the atmosphere may contribute to this appearance more than a hundred fathoms underground. It is true, the Mines are continually fraught with a kind of warm vapour, which may be seen to arise from every shaft, when the air is cool, clear, and dense; and it may be supposed, that, as it ascends through the natural and artificial outlets of its womb, it is more or less condensed by the external air, in proportion to the rarity or density thereof. But if this solution appears plausible to some, we desire to be informed, why this should not be more apparent, when the wind blows from the north; and why this vapour, if not of the dry kind, should not be condensed in the shafts and gunnies (hollows) of a Lode, after the manner of rain, as other vapours are, and, therefore, be as distinguishable in its production, as in its existence?

From



From the foregoing proofs, that rain Water penetrates to the depths of the earth, we may be satisfied, that the opinion of De la Hire, Calcott, and others, who say, rain Water does not sink two feet below the surface, is altogether erroneous; for if it does not enter into the bowels of the earth, what else should occasion so vast an increase thereof, at, or soon after, its discharge from the clouds? So apparent is this fact, that if the great increase and collection of Water from the heavens, before mentioned, be obstructed in its circulation, and collected into large bodies, by the peculiar matter or form of its recipient, it may, and has many times appeared to be the cause of local earthquakes; which, we apprehend, may proceed from the Water of higher grounds, that gets underneath a slimy viscous earth or clay, until the force of the confined Water moves it upward, and carries the earth along with it in its passage and irruption; of which we may produce an instance, at Kappanihane in Ireland, A. D. 1697; another of Pilling Moss, in 1745; and a more recent one, in the late accounts we have had, of Solway Moss in North-Britain:

———— As if on earth,  
Winds under ground, or Waters, forcing way,  
Side-long had push'd a mountain from his seat,  
Half sunk with all his pines.

MILTON.

As for those earthquakes, which are more general, tremendous, and destructive; it is probable they are caused by the combination of different salts, juices, sulphur, or some other inflammable matter, that rarifies and agitates the air, in the deep caverns of the earth; whereby a convulsion is caused, which sometimes breaks out in flames at the surface; and sometimes shocks and gives the earth a tremulous motion, without any visible fire, perhaps for want of sufficient matter to ignite. For, if you add twenty pounds of sulphur to twenty of iron filings, and mix these with water, so as to form a paste; in six or seven hours after they have been buried a foot and half under ground, the earth will begin to tremble, crack, and smoke, and fire and flame will burst through; so that there wants only a sufficient quantity of this matter, to produce a true Etna. If it was supposed to burst out under the sea, it might occasion a new island: and we believe Delos, Rhodes, and some other islands were produced by the same, or such like submarine volcano. (Pliny) An island in the Archipelago on the coast of Natolia,



Natolia, in 1707; another among the Azores, in 1720; and four islands in a lake, in the Manilla, A. D. 1750; are productions in the present century, from the same cause. Dr. Worthington advances, "That the sole cause of the formation of mountains, was an universal earthquake."

The immense congregation of Iron, Sulphur, and other combustible materials, with which our mining district is so replete, would naturally incline us to believe our situation more obnoxious to subterranean throes, than any other part of Great-Britain. But, by the mercy of our GRACIOUS PRESERVER, we have hitherto felt nothing peculiarly to alarm us, on account of our situation. Many are of opinion, that our numerous shafts, adits, and other apertures, are the principal outlets, through which the mineral effluvia of our Lodes exhale and escape, without prejudice to the lives and safety of the inhabitants.

Another prodigious, general, and effective cause of earthquakes, is an electric æther in the atmosphere, according to the opinion of the learned Dr. Stukely; and from this force, extended to a considerable distance, through various substances, of different textures and densities, we may attribute the destruction of no less than thirteen great and noble cities in Asia Minor, in one minute's time, in the year of our Lord 17. Another earthquake in Peru, anno 1586, extended 900 miles; and we may add that memorable earthquake in our own days, upon the 1st of November 1755, which destroyed Lisbon, and was felt over almost half the habitable globe.

We may apply either of these causes, under such certain situations and circumstances, as may incline our judgment to preponderate. But may not all of them operate for the same effect? We think they may: and who can say, it is not so? For with Job we may say, "Lo, these are parts of God's ways; but how little a portion is heard of him? And the thunder of his power who can understand?" Omnipotence being the directing cause, all things are equally accomplished by the natural instruments of his power: and when we hear the thunder of his voice, and see the mightiness of his power, the dreadful, though partial convulsions, of an angry, yet merciful God; ought we not to meditate upon the hitherto harmless, though alarming tokens we have had of his indignation, tempered with love? Of all the natural warnings of his displeasure, those of earthquakes are most terrifick; coming like a thief in the night,  
when



when the sons of men know not of it ! We may flee from the pestilence, the famine, and the sword ; we may avoid the dangers of the sea, and provide against fire ; we may secure our habitations from lightening, tempests, inundations ; we may, by the assistance of skilful applications, and the wisdom of the physician, baffle the attacks of disease, to the prolongation of our lives. But no flight, no prudence, no philosophy, no delay, can obviate this desolation : for, it is as the presence of God ! How thankful then, ought we to be ! how humbly should we walk before him, who hath hitherto spared us, in the midst of his judgments ! O Lord God ; for the abundance of our sins, thou art greatly to be feared ; and yet we see that in great mercy, thou presidest over all thy works !

Though it is remarkable, that the Water of a Mine, at or near the sea cliffs, is very easy and small, especially when the Mine is sunk under low Water mark, or works under the sea ; yet it is absolutely certain, that it is less in proportion to the ground discovered under the level of the sea, than above. How this should be, is one of the most puzzling questions that can be put to the Miners, who, to a man, ingenuously confess their ignorance of the true cause of it. The gentleman and the philosopher are equally at a loss to account for this fact, except Mr. Bennallack, who says, “ That in the places where he has  
 “ had opportunities of judging properly, the only apparent  
 “ cause is, that the strata being more compact, and conse-  
 “ quently more free from those sundry kinds of fissures, which  
 “ the Miners in general call Cafes, there are not the same con-  
 “ veyances for the Waters of the surrounding country to flow  
 “ into the Mine.” In Huel-Towan in the parish of St. Agnes, where they are not many fathoms under low Water mark, the facts of the Water being less, and the ground more compact, are incontestible ; nor, in that place, does any other matter appear conducive to it. We believe this may be one natural cause in some particular places, but it cannot be always so ; and we likewise believe, that there may be other contributing matters, which may be different, in different situations. We will have recourse to the most simple and plain enquiry into the form and texture of the earth, in the solution of this phenomenon, distinct from our knowledge of the pressure and gravity of fluids : but before we proceed, we beg leave to illustrate our subject, by a very remarkable history of a case in point.

The



The Mine of Huel-Cock in the parish of St. Just, is wrought eighty fathoms in length, under the sea, beyond low Water mark; and the sea, in some places, is but three fathoms over the back of the workings; infomuch, that the Tinnors underneath hear the break, flux, ebb, and reflux of every wave, which, upon the beach overhead, may be said to have had the run of the Atlantick-ocean for many hundred leagues; and, consequently, are amazingly powerful and boisterous. They also hear the rumbling noise of every nodule and fragment of rock, which are continually rolling upon the submarine stratum; which, altogether, make a kind of thundering roar, that will surprise and fearfully engage the attention of the curious stranger. Add to this, that several parts of the Lode, which were richer than others, have been very indiscreetly hulked and worked within four feet of the sea; whereby, in violent stormy weather, the noise overhead has been so tremendous, that the workmen have many times deserted their labour under the greatest fear, lest the sea might break in upon them. This proximity of the sea over the workmen, without their being incommoded by the salt Water, is more wonderful, than the account which Dr. Stukley gives, of his descending into a coal pit at Whitehaven one hundred and fifty fathoms deep, till he came under the very bed of the ocean, where ships were sailing over his head; being at that time, deeper under-ground by the perpendicular, than any part of the ocean between England and Ireland. In his case, there is a vast thickness of strata between the Mine and the sea; but, at Huel-Cock, they have only a crust between, at most; and though, in one place, they have barely four feet of stratum to preserve them from the raging sea, yet they have rarely more than a little dribble of salt water, which they occasionally stop with oakum or clay, inserted in the crannies through which it issues. In a Lead Mine in Perran Zabuloe, formerly wrought under the sea, they were sometimes sensible of a capillary stream of salt Water, which they likewise prevented by the same means, whenever they perceived it.

Now, a very large proportion of our Mine Water is temporary; and, as I have said before, is denominated Top Water, which in great part sinks into the Mine immediately where it falls, by the peculiar loose texture of strata where Mines are, which must be cavernous and fissured, to constitute and form those receptacles of mineral particles called Lodes, and their lateral branches: consequently, the ready access of this Top Water, must be very sensibly perceived by the Miners; and



more especially must the difference be seen, when compared with a part of the same Mine under the sea, entirely free from such Water. The submarine strata of our Mines, must be totally impervious to any Waters, which fall into the sea. It cannot be otherwise. So that such parts of the Mines, are quite free of any Water locally above them.

The next paradoxical consideration that occurs, is to account for the absence of the superfluent salt Water, from the submarine workings.

We have observed a kind of slime or mucus upon some marine strata, which is so glutinous as to fill up every pore and cranny of the rock that is covered with it. This glutinous slime, we take to be a marine soil or earth, for the vegetation of grass, ore weed, and other sea plants; the sea is replete with it: every ship at the end of a long voyage has her bottom covered with it, and a marine grass vegetates therein. This viscous matter thickens by degrees, as if purposely designed to hinder the Water from penetrating into the earth; which it most effectually does, according to my judgment of the matter. Upon a rough beach, this slime may not be equally deposited, by means of the constant friction of rocky fragments under the action of the tide; and other parts may be covered with loose sand and pebbles, which afford no bed or rest for this soil. In such case, it penetrates through the surface, and finds a quiet depository, in the small clefts and interstices of the strata, below the force and action of the sea; and in time, probably, incrustates and fills up those very minute fissures, with a petrifactive gluten, if it is at all charged with such principles; and we have neither theory or reason to dissent from that opinion, as we think it must partake of every principle which is soluble by Air, Water, and Salt.

Thus have we demonstrated, that Top Water does not specifically descend into the Mine where it falls upon the sea, and consequently that part of the Mine cannot be incommoded thereby like other parts; and that the minute pores and fissures of submarine strata are almost totally impenetrable by salt Water, through means of the petrifactive tenacious gluten, with which they are smeared. The facts, added to the compact, or close conformation of strata in some parts of the earth under the sea, will serve, as we presume, for a proper solution of this difficult problem.

That



That there is a petrifying quality in the earth or its juices, is manifest to those who are conversant in Mining, and consider the nature of the Stones which are dug out of the ground; for they frequently meet with large solid rocks, composed of several small Stones united together, of different forms, colours, and properties, with respect to the same individual Rock or Stone; which is a manifest indication, that its different parts were originally loose and distinct from each other, until they were conjoined into an entire solid mass, by something of a petrifying principle, which cemented them together. It is more than probable that Stones, like Salts, and most Fossils, are the productions of a suspended lapidifick matter in a fluid, which gradually hardens into Stone, by the evaporation of its finer parts.

Mons. Tournefort observes, “ That in the famous labyrinth  
“ of Crete, several persons had engraved their names in the  
“ rock, of which its walls are formed; and that the letters so  
“ engraven, instead of being hollow, as they were at first, stood  
“ out from the surface of the rock.” This can no otherwise be accounted for, than by supposing the cavities of the letters filled insensibly with matter issuing from the substance of the rock, even in more abundance than was needful to fill them. Letters cut hollow in a living rock of Limestone, fill up, in a course of years, with spar; and what were made in Creux, are found in Relief. This has been seen in Gothland, by the eminent Swede. The spar stands higher, as the time is more distant; and has been seen, in some places, a quarter of an inch above the level of the surface. (Hill)

Thus is the wound of a knife healed up, much as the fracture of a bone is consolidated, by a callus formed of the extravasated nutritious juice, which rises above the surface of the bone. Such cicatrices have been observed to be formed on other Stones, which were reunited, after they had been accidentally broken. The many instances we have of those cicatrices in Granite or Moorstone, upon the surface of every karn or rocky hill in Cornwall and Devon, will clearly put this matter out of dispute; as our Stone-masons always chuse such for splitting in the very cicatrix, which generally is about a quarter of an inch above the other superficies of the stone; and splits with more ease, than any other part of the same block, because it was before separated, and had been again reunited by its petrifactive gluten. Hence it is manifest, that the same juice which nourishes them,  
serves



serves to rejoin their parts when broken. We find, that Water is so full of stony matter, and so ready in part to turn into Stone, that it fills every crack and crevice of the most solid rocks with Stone of the most pure kind, Spar or Chrystal. If Water contains a quantity of stony matter, then Water is able, in some slow way and in the course of nature, to dissolve this stony matter, though we cannot make it do so in any of our operations. If Water can dissolve stony matter, Water may take it out of one place of the earth, and carry it to another. It will perhaps appear, that the original power of encrusting and petrifying lies in the earths and clays themselves, a thing few have thought upon; and that the Water serves as a vehicle to carry the stony matter out of one place into another. All this being understood, it seems natural to suppose, that not only the petrified substances found in the earth in some places, but even the beds of Stones themselves, owe their origin to these particles contained in the earth, and to the agency of Water, which can dissolve, remove, disperse, separate, and bring them together again in various forms and combinations. If Water can dissolve these particles of stony matter, Water can in the same manner keep them suspended for a time, and let them gradually separate and congeal afterwards. Water, therefore, can act, when it is thus loaded with particles, as a cement or agglutinating liquor to bind them together, or to introduce changes in them. For instance, Water can fill the pores of clay; and if such Water fill the pores of a bed of this earth, and afterwards draining gently away, leave that stony matter behind, it does, in that case, cement that bed of clay into a bed of Stone. (Owen).

This petrifactive quality, which serves to conjoin and cement Stones together, we must allow capable of inclosing, within itself, sundry extraneous bodies, which it may be in contact with, such as bones, shell-fish, and many other things, of which natural history has given us such very strange accounts. I shall add a particular domestick instance, of which we have been very credibly informed: namely, that some few years since, at this town of Redruth in Cornwall, some labourers being put to clear and level the street for a pavement, they found a piece of hard Stone in the ground, with abundance of common small pins of Brass, interspersed in and throughout the Stone, in such manner and form, that all those who saw it afterwards, were convinced, it was not done artificially, but that the Stone was formed and produced by petrification, subsequent to the time the pins were dropped into the ground. Dr. Plot, in his Natural History



History of Staffordshire, says, "That near Newcastle under-  
" line, there was found a Stone with a man's skull, teeth and  
" all, inclosed in it!"

From what has been said, I presume it may not be absurd to infer, that every earth or clay, in some places, may be converted to Stone in process of time, at such a depth where it is undisturbed, by being never lacerated nor molested; and also where it abounds with an uncommon quantity of juices, of a lapidescent quality: but this property being extenuated or destroyed, the earthy Stones may, not improbably, again return to their primitive earth or clay. Thus we see some sorts of Stone, when dug out of the ground, and exposed to the air for a considerable time, do moulder again to earth, at least in appearance; while others, of an earthlike quality, are indurated, and become more compact and durable, by lying above ground. Hence some have imagined, that all the terrestrial globe, and every individual inanimate thing contained in it, is nothing else but Water, rendered solid by petrification.

Thales, the Milesian, held Water to be the first principle of all natural bodies, of which they consist, and into which they resolve. He endeavours to establish this opinion, by arguments drawn from the origin and continuation of most things: first, because the seminal and generating principle of all animals, is humid; and secondly, because all kinds of plants are so much nourished by Water, that when they want moisture, they wither and decay. Some have not hesitated to father this philosophy on Moses. The great prince of philosophers, Aristotle, with Lucretius, Theophrastus, and Leonardus, were of the same opinion. Nay, Hippocrates lays great stress upon it; and of later days the great Sendivogius, with the most learned of the Spagyrist, who own that Water is an universal principle.

This Crystalline or lapidifick juice, Mons. Geoffroy says, is more heavy and fixed than simple Water; and consequently is not evaporated with it, but is left behind: and thus the formation of Crystal is perfectly like that of the Crystals of salts. For these Crystals only arise with those regular figures they affect, as when a Water impregnated with salts is slowly evaporated at perfect rest in a moist place. The evaporation of the Water is necessary, that it may not keep the salts too far asunder; and the slowness of the evaporation, that the salts may have time to take that arrangement, which agrees best with  
H their



their respective figures. The application of this to Rock Crystal, is obvious: it is only needful to conceive, that a Water charged with a quantity of Crystalline juice, had insinuated itself through the clefts of some Rock, where the aqueous part gradually evaporated.

An unsaline Crystal earth, though not in such plenty as a saline, is yet as intimately mixed in Water, nay in the fullest degree of clearness passes through the closest strainers; consequently, the crystallization of salt is here not improperly alleged for a model or pattern. (Henckell.)

It must be considered, that this Crystalline juice is not equally diffused in all parts of the Mine; so that Rock Crystal would not arise in all places, even setting aside the necessity of other concurrent circumstances, which do not often meet. If the Water impregnated with Crystalline juice happens to penetrate a mass of earth, which is the most usual case, it will connect and bind together the parts thereof by means of this juice; and afterwards, in proportion as the watery part evaporates, the compound will grow harder, and at last become Stone. Add to this, that it will approach nearer to the nature of Crystal, that is, it will be more hard and transparent, according as the quantity of that juice is greater; and at the same time have a finer grain, according as the molecules of the earth are smaller and more homogeneous. Of this kind are Marbles and Alabasters; in some of which, one may discern threads or veins, as transparent as if they were wholly Crystal. The Stones most opposite hereto, and most imperfect, are Chalk and Boles, which are little else besides earth ill bound together, with a very small proportion of Crystalline juice, which leaves them still friable. Between these, it is easy to imagine, there are infinite degrees.

Camillus Leonardus says, that “Stones which abound most  
“with the terrene, are thick and dark; neither are they free  
“from Water.” And Aristotle, in his book of Minerals, expressly says, “Pure earth doth not become a Stone, because  
“it makes no continuation, but a brittleness; the prevalent  
“driness in it, permits it not to conglutinate; and so by the  
“aqueous mixed with the terrene, Stones are made.” By the aqueous, he means an unctuous or viscous humidity, proportioned with a terrene; and according to the disposition or proportion of



of such humidity with the dry terrene, divers and various Stones are produced.

The particular circumstances which attend the formation of Stones, vary the effect of these general principles divers ways. For instance, if a portion of this juice, diluted in Water, happens to be surrounded with earth, and the juice be not in quantity sufficient to petrify the whole earth as fast as the Water evaporates; there will arise a mass partly crystalline and transparent, and partly opaque, dissimilar, and earthy: and such we presume is the difference of the Caples of our Lodes, and the contiguous strata; the former being sometimes more compact and firm by its contiguity to the juice percolating the vein, and the latter less so, by its proportional distance from the Lode. If the same Crystalline juice be in the middle of the mass, only the middle will have a Crystalline appearance and firmness; such as the huge rocks of Crystal (Quartz) we often see rise out of a vein or lode, which commonly implies a failure of Metal in that part of a Mine.

This Cement may be divided into three degrees of purity: the first a coarse Quartz, which is the most impure, and covets no particular form; the second is Crystal, which forms hexagonal columns, cuspides, and pyramids, and is the connecting basis of Slate, Killas, Granite, or Moorstone, &c. But if by a still greater degree of purity, the Stone becomes specifically heavier, of better lustre, and resists fire almost to immutability, then it is called a Diamond; and the Ruby, Sapphire, Amethyst, &c. are but this Diamond tinged and reduced, as to lustre and hardness, by some metalline tint.

What is vulgarly called Spar with us, and which is so plentifully scattered upon the surface of every heathy common, is not the real Spar; and is, by most Lithologists, better known by the German name of Quartz, for want of a proper English appellative. Spar, by itself clear and unmixed, is very rarely found in this county. Indeed, the reason of its scarcity is, because we have little or no calcarious strata to produce it. The late Sir John Hill, in his history of Spar, which he divides into eighty-nine species, says, that Limestone is only coloured hardened Chalk, and Marble is the same. Marble is a purer Limestone, and Limestone a courser Marble. Water being saturated with the principles of Sulphur, and with Chalk, keeps on its gradual course horizontally through the lime rock,  
till



till it meets a fissure, a perpendicular crack or opening, dividing one part of the rock from another. Here it ouzes forth; and meeting with a lighter air, suspends and evaporates slowly.

We have said before, that slow evaporation, and perfect rest, are the requisites of Crystallization. The Sulphur and pure Chalk thus united, form one solid body; which crystallizing gradually, sometimes appear in regular rhomboidal particles; and is the substance properly called Spar. That the Spar formed in the fissures of rocks, is thus washed out of Limestone itself, is certain; because none but Limestone rocks have Spar in their fissures. Rocks of a Crystalline matter, or formed of a vitrifiable Stone, have always Crystal, but never Spar, in their cracks or fissures. It grows continually; for wheresoever there is a crack in a Limestone rock, new or old, Spar always fills, and overruns the surface. Therefore the calcarious nature of Spar, is of its essence; and no form, nor all the other characters in the world, could constitute any production a Spar, that wanted this. It always ferments with acids, and burns to lime.

The formation of Spar is yet a subject of enquiry. Its atoms are all Spar; each particle, into which we can without violence divide it, is the same in all respects as the whole: and as the Fossil world admits of no generation by egg or seed, it seems most probable, that all the variety of forms, in which we behold this Protean Mineral, are owing to no cause but the arrangement of rhombs, into as many forms as they are capable of producing. It fills the cracks of its own rocks, and of no other; for Crystal columns rise from Crystalline rocks; and from Metalline masses fractured grows Mundick; each separated from the great mixed body we see split, and each formed into figures by its own laws.

The obvious scarcity of Spar in this county, is absolutely proved in the almost total absence of Limestone, whence it is mineralized; neither have we yet seen a perfect Sparry Rhomb in Cornwall.

It may be difficult to persuade the vulgar Cornish, that we have little or no Spar in our Mines; but that so it is, every unprejudiced observer may be convinced by the testimony of his own senses. They denominate every species of Quartz and Crystal indiscriminately, except the Pseudo-Adamantes, Spar; so that in their opinion almost all the streets in the county are  
paved



paved with Spar instead of Quartz; and with them every Crystalline rock under-ground bears the same name. It is time, however, that this confusion and misnomer of Fossils should be abolished, and such mistakes and false distinctions laid aside for the sake of order and propriety. Be it, therefore, henceforth remembered, that all those masses of white and yellowish Stones scattered upon the surface of our lanes and commons, which are only used for paving and hedging, are Quartz, and have no Spar in them. If they were truly of a Sparry texture, they would save us much expence and labour for Limestone, which is now imported from Wales and Devonshire; besides the cheap and ready manure they would afford, for the cultivation of our land.

Plain Crystal hardens into any figure, of which its own gravity, and the matter in which it forms, will admit; and we find it veined in all our Killas, Caple, and every part of our strata, that is generally and vulgarly denominated the Country by our Tinnors; yet it is perfect Crystal, breaks irregularly, yields fire plentifully, is very hard to the graver, and will not ferment with Aqua Fortis. It will sometimes form itself in hexagonal opaque columns, cuspides, and pyramids, of an uncommon large size, but of no value.

But if those pyramids are of a fine pellucid Water, they become the Pseudo-Adamantes of the purer kind, and are thence eminently called Cornish Diamonds; and are by Dr. Grew, and others, reckoned superior to the Bristol Stone, and every other diaphanous Crystallization in Great-Britain.

### C H A P. III.

Of Metals and Minerals, and the Fluxes for assaying them.

**T**H E inferior Metals, especially Copper and Iron, are the easiest of any to be dissolved by most acid menstrua, their parts being very different, unequal, and heterogeneous in themselves, and more susceptible of any outward force or impression. We take this to be the cause, why these two Metals are more subject than others to be corroded and injured by exposure to the air, which abounds with volatile acid salts, and  
I thereby



thereby becomes a menstruum, that readily adheres to, resolves, and corrupts those tender imperfect Metals; whereas Gold and Silver, whose parts are most solid, dense, and homogeneous, receive little or no damage by contact of the acid salts. Lead and Tin likewise, not being easily resolvable by Aqua Fortis or any water of that kind, are not near so soon prejudiced by the saline pungent particles of air, as Copper and Iron are; which probably happens, because they have a greater degree of similarity of parts better united; or because they contain somewhat that approaches to the nature of Sulphur, whose property it is to resist all acid menstrea.

The word Ore, as also the word Mineral, in the largest acceptation, comprehends any impure Concrete or Fossil, that contains either a Metal, Semi-metal, or Mineral juice; but if the species of the thing signified, be added to the word, then the particular sense or meaning of the expression is limited and denoted. Thus it is usual to say Copper Ore, Lead Ore, &c. The Ore of Antimony, The Minerals of Copper, of Lead, and the like; so that the words Ore, and Mineral, are only synonymous terms, that imply any kind of Mineral Fossil without expressing its nature. Nevertheless, a barren Mineral Fossil, which yields no produce in the fire, cannot well be termed an Ore, though it is called a Mineral; for it is improper to say, the Ore of Mundick, &c. Custom however prevails so much in the terms of our Miners, that they often call such Minerals as they know are of no value, by the name of Ores; and, therefore, to be more clearly understood in what follows, by the word Ore, I mean only a Fossil or Concrete, which produces real Metal, as Gold, Silver, Copper, Tin, Lead, Iron, and also Quicksilver; by the word Mineral, I confine myself to the more crude Fossils or Concretes, which yield Sulphur, Vitriol, and other such brittle bodies; and by the word Semi-metal, I mean Antimony, Bismuth, and Cobalt. I presume it necessary to make this distinction, to prevent the perplexity in which those who are but little acquainted with the science of Metals, are often involved.

All things in the bowels of the earth, which occur to the consideration of a Mineralist, are reducible to the following classes: first, Earths and Stones; secondly, Concrete Inspissated Juices or Bitumens, as also those which are liquid; thirdly, Semi-metals; and fourthly, Metals. We shall speak of each of these in their proper order.

First



First, of Earths ; of which there are many sorts of different colours and natures, whether simple, or compound ; and are to be esteemed among Ores or Metals, no further than with regard to the plenty or scarcity of Metals or Minerals they seem to indicate ; or else as indications which may be the best method to extract the Metal that is intermixed with them : but I shall not here prosecute the inquiry into this subject, because I shall have occasion to take particular notice of it hereafter.

We shall likewise say nothing of many remarkable Earths and Boles, as they have little or no connexion with Mines or Metals ; such as Bole Armoniack, Terra Lemnia, Fuller's Earth, Lac Lunæ, Spanish Bole and Terra Sigillata, except the Steatites or Soap Stone, which is in such plenty, and so diversified and beautiful, at the Lizard Point, as to have invited many Fossilists to inspect its situation, colours, quantity, and properties. The varieties of this Fossil, at the Lizard only, are divided by Dr. Borlase into ten, whose No. 1 which is the Steatites quæ paratonium antiquorum, No. 13 of Da Costa, and the argella albissima ponderosa tenax p. 17 of Hill, is found in veins about two fingers breadth at Gew-Grez cove, where it is carefully selected from the other sorts, barrelled up, and almost wholly engrossed by people employed under the managers of the Porcelain Manufactories. But the No. 14 of Da Costa, which he describes as taken by himself from our soap rock, he eminently denominates Steatites vera ; which I think he ought to have stiled the Steatites Cornubiæ, as he recommends it to the China manufactories lately established in this kingdom, and doubts not but we shall be able to surpass the manufactories of all other European nations, since none have those Steatitiæ in such plenty and so fine. It is remarkable, that letters written with Soap-stone upon glass, though insensibly fixed, are not to be moved by washing, but always appear upon being moistened by the breath.

The curious memoir in the transactions of the Royal Academy of Sciences at Paris, for 1727, communicated by the learned and indefatigable Monsieur de Reaumur, fully informs us of the art of making Porcelain, and the true substances used for that purpose by the Chinese : he has in that memoir judiciously considered China as a Semi-vitrification, and on the principles of burning the ware to that exact state, he has established the perfection of the art. Now as all Earths vitrify, it is evident no true Porcelain can be made only of Clays, but other necessary



fary substances are required to hinder their perfect vitrification ; and for such substances they can have recourse to the Talky class, the Fossils of which almost evade the force of fire, and on that account furnish us with the finest and best ingredients. On this principle it is evident, that no species of clay whatever, can be finer or fitter for the making up of China than these hardened Talky Soap Clays, wherein nature has blended the necessary Fossils, Talk and Clay, ready for our use. Even a very fine common white Clay, properly tempered and mixed in suitable proportions with our moist Talky Granite, or Moorstone, impalpably triturated, may furnish us with the properest materials to be had for a China manufactory. It remains, however, still to be observed, that the Clay for China must be very fine, extremely white, and cleared from every heterogeneous soil ; for which reason, in St. Stephen's and Breage parishes, they pass it through many lotions with clear water, before it is put into casks to be sent off. Where we have seen a natural or adventitious mixture of Clay and Granite, with us, commonly known by the name of Grouan Clay, it has always answered for bricks to build fire places and furnaces with, equal to Stourbridge and other Clays ; insomuch that plenty of it has been sent to Bristol, and the Welch Copper-works, for the purposes before mentioned ; besides that famous yellow Clay in the parish of Lannant, which has produced such an handsome income every year to Humphry Mackworth Praed, Esq;. The manufactory, which was set up within these few years at Truro, for the making of crucibles, is a very notorious proof of the strength of our Clays, when mixed with Granite, to resist the most intense fire : no other crucibles are now used by our assayers ; and the inventor has received the appointed premium for the discovery, from The Society for the encouragement of Arts, Manufactures, and Commerce. These crucibles have not one leaky nest among fifty ; and the foreign pots, which were used till lately, had scarcely fifty sound crucibles among a hundred ; so that if the proprietor knows how to advance his interest, he may export great quantities every year for foreign use, and save a considerable sum to this kingdom, which formerly went out of it for this necessary article in metallurgy.

Stones are either common, or precious. There are also several sorts of Stones peculiar to Metals, which are frequently met with in Mines, that, by their colours and consistence, often denote either a profitable or barren Mine ; such as Spar Stones, Quartz, and Fluors resembling Crystal, by the Germans termed



termed Flusse, from their propensity to melt in the fire, which are no bad symptoms of Metals, except those Stones be hard, opaque, and untractable. There are several other kinds of Stones worthy of notice, which we omit here, and refer to their proper places, when we shall speak of the different kinds of Lodes with respect to the Earth and Stones they contain. Of precious Stones, there are great diversities of kinds, colours, and value; yet there are few met with by Mining in Europe, of any great intrinsic worth: the knowledge of precious Stones, however, is not properly the business of a Miner.

Secondly, by Inspissated Juices, and Mineral Waters, we mean all Mineral Substances, dug, or flowing out of the earth, either in a coagulated or liquid form. Of the latter sort we shall not speak further at present, but shall divide those of the first kind into three sorts, viz. Saline, Sulphureous, and Acid. Of the first are Sal Gem, or Sal Fossile, Nitre, and the like; of the second, are most kinds of Bitumens, as Naptha, Asphaltos or Pix Judaica, Petroleum, Sulphur, Pit-coal, &c. Lastly, the acid sorts are Vitriol, or Copperas, of which there are great varieties, produced either by nature or art. Native Vitriol is made in the bowels of the earth of an aqueous liquor impregnated with an acid salt, and of a cupreous or martial Mineral, strictly united, both to a combustible sulphureous substance, and to another body of a more fixed terrestrial nature. (Boyle). The common green Vitriol or Copperas of the shops, is an artificial production; great quantities of which, are manufactured by my friend Ephraim Reinhold Seehl, Chymist, at Blackwall and Deptford.

Dr. Rouby, a curious foreigner, set on foot a manufactory of Roman or Blue Vitriol, at Treleigh in Redruth, about five and twenty years since; which dropped, only with a loss of ninety pounds, by means of some disputes and disagreements among the persons concerned. It was collected from the waters which were left from the lotions of Black Tin, after it had been calcined in the burning-house, for the discharge of its Mundick. This water, being strongly impregnated with vitriolick particles, after it had been decanted clear from its dregs, was kept constantly boiling, by a gentle fire, for seven or eight days, in a leaden boiler; when being evaporated to a pellicle, it was drawn off, and set to crystallize in proper vessels. The time for crystallization, was generally three or five days, according to the different degrees of impregnation of the water; eight

K

tons



tons of which, well saturated with vitriolick particles, would yield a ton of very fine blue Vitriol, far superior to the Hungarian, or any other I have yet seen; at that time, worth about eighty pounds, and the expence of making about fifty. The materials are so plenty with us, that we could undertake to supply the whole world with this merchandise from Cornwall, by a cheaper process than the foregoing. But the domestick demand for this salt, does not exceed twelve or fourteen tons ~~per~~ annum; and our remote distance from the centre of the kingdom, will occasion so great a charge in commission, freight, carriage, &c. that it will hardly be worth the trouble and expence of apparatus and making. Besides, without a patent for the sole making and vending thereof, it would soon be in the hands of too many persons, for the continuance and prosperity of the undertaking. Add to this, that they now make it at Birmingham of what they call pickle, and render it at nearly half the price they formerly sold it for: and we imagine, that the continent may be supplied from the Cyprus and Hungarian Mines with an inferior Vitriol, of course cheaper, and what may answer their purpose almost as well.

There are also other sorts of Copperas, which are distinguished by their different colours, as Chalcitis, Melentaria, &c. which are only different degrees of the same recrementitious Mineral, and are now very little regarded. Other acid Fossils, are native or rock Alum, or common Alum, which is made by art; but the Alom de Pluma, Alumen Plumosum, seems rather to be the Amianthus, Asbestos, or Earth Flax, whose fibres endure the fire and will not burn. The last, however, is rather a Stone than a Mineral; and has been found in the parishes of Landawednack and St. Clare in Cornwall very fine and perfect. Dr. Grew in his Museum of the Royal Society, says, "There is a kind of Asbestos, which grows in veins in a Clay and Munday Lode, between beds of a greenish earth, in our Cornish Mines;" but we never yet saw any thing of the kind in them.

The sublimate of our white Mundick, if carefully swept from the funnels of our burning-houses, and well separated from the bituminous foot and smoke mixed with it, may produce, by confined fusion, some of the best white Arsenick; and the more yellow Mundick may give a fine delicate straw coloured sort. If it is not sufficient of itself, an addition of one tenth Sulphur, will perfectly do it; and by a further addition of Sulphur, a  
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very fine red Arsenick may be obtained. But, if I am rightly informed, the most profitable torture this Mineral can undergo, is the reducing of it into a beautiful Ultramarine, which is more valuable than Gold itself.

The Society for the Encouragement of Arts, has repeatedly offered premiums for the best composition to pay over ships bottoms, in order to defend them against marine worms, which abound so much in some parts of the East and West-Indian seas, that vessels new off the stocks, have been frightfully bored in their first voyage. Our county being altogether maritime, and the Mines being situated in the most narrow part of it, between the two channels, many of our adroit Tinnners are equally conversant with naval and subterranean affairs. So true is this, that in St. Ives and Lelant, during the fishing season, they are wholly employed upon the water, to the great hinderance of the adjacent Mines; and when the fishing craft is laid up against the next season, the fishermen again become Tinnners, and dive for employment into the depths of the earth. We have more than one instance, of a common labouring Tinner, after he has many years worked under-ground, becoming so complete a sailor, as to be entrusted with the command of a large vessel to the Baltick, the Levant, or any other part of the globe. This may seem strange to some of our readers; but if it were much to our present purpose, we could make it appear, that there is in some parts of the two employments a great analogy, notwithstanding the elemental difference. It is a maxim among us, that a good Tinner makes a handy Sailor.

It is not, therefore, to be wondered at, that many of our Tinnners and Sailors have reciprocally attended to the object of the above-mentioned premium: the poisonous qualities of our Mundick have engrossed their attention accordingly; and they have complied with every direction in regard to the payment of timber with this poison, but all to no purpose. We have tried it in a preparation of our own, subtilized in such manner, as to be free from those cracks after it is laid on, to which the Mineral, by its specifick gravity, when mixed with pitch and tar, is subject. It will be needless to describe how we have tried it upon some of his Majesty's packet boats at Falmouth, as the experiments did but partially succeed to our wish: suffice it to say, that no payment, however deleterious to animal life, will answer our expectations, unless it can be laid on in such manner, and of such consistence, as to be equally smooth and free



free from the least crack or separation; and be of such impenetrable hardness when dry, as to equal Metal, which alone is proof against the piercing auger of the Tereido: even petrified wood may be bored by the jaws of this worm, which we are told will penetrate Stone itself. Mons. de la Voye speaks of an ancient wall in the Benedictines abbey at Caen in Normandy, so eaten with worms, that a man may run his hand into most of the cavities. (Philo. Trans.) Hence we will take upon us to say, that no payment whatever, even the most poisonous, will effect the resistance required; for the worm first of all introduces its auger, which is a callous, shell-like, insensible instrument, through the matter which is laid upon the wood, and continues working, till it has made a deep impression into the substance of the timber, when it takes a turn, and works along with the grain of the wood, which it then feeds upon, and not before: whereby we see, it has escaped beyond the designed cause of its destruction, before the vital or animal part of it comes into action; so that we may be assured, that no payment will secure our ships bottoms, but impenetrability itself.

A quantity of the preparation here spoken of, was sent some time ago to an eminent ship-builder at Rotherhithe, who returned for answer, "That he was very well satisfied, the composition would fulfil the most sanguine expectations; but, he thought it not the proper business of a shipwright, to advance or encourage any such undertaking, however laudable in the eye of the publick; and he supposed every other artificer in his way, would be of the same mind:" and in consequence of this reasoning, a few hundreds weight of the preparation were thrown into the Thames. We likewise recommended a trial of it to another ship-builder in this county, who ingenuously said, "That he would first wait some trials of his own upon Munk very finely pulverized:" but he would not regard, or did not understand, my reasons against the bare possibility of his success.

The effect, however, that cannot be obtained by external application in the payment of a ship's bottom, may be produced by previously saturating the planks of which the bottom is formed. The planks that are laid upon the bottom or side of a ship, are first seasoned in hot water, in order that they may be flexible, and yield to the form and shape of the mould, upon which they are laid. It is, therefore, only necessary to infuse and mix with the boiling medium, a quantity of the above-mentioned



mentioned composition, which is one of the most active, impalpable, and subtil mineral minimæ, specifically to be obtained; and will insinuate itself and enter into the pores and vascular constitution of the timber, which being thus wholly saturated will have all the power and aculeated exertion of the most effective poison; so that if the *Teredo* penetrates through the outward part of the wood, whenever he turns to feed upon the grain of it, he will be immediately destroyed. This digression will, we trust, be excused by many of our readers, on account of the importance of the subject to commerce and navigation.

We shall now go on to observe, that those rapacious poisonous Minerals are often intermixed with Ores and Metals in the earth, though not so often distinguishable; and from thence in a great measure proceed that asperity and volatility which often happen to Ores in the fire, and which an unskilful refiner is not capable of understanding and correcting. We shall, therefore, in few words, endeavour to give an account of those fluxes, which are mostly useful in the small examen of Metals by fire; in which business the assayer or artificer ought duly to know and consider the different properties of acids, alkalies, and neutral salts; and how they act with each other and agree with Metals.

Sal Nitre, or Salt Petre, is a native Salt; and is almost peculiarly the product of the East-Indies, from whence our East-India company import amazing quantities. They have in a great measure monopolized this article; and its vast consumption in the manufactory of gunpowder, &c. must render it a very important branch of their trade. It is also factitious, and may be made at home from the offals of slaughter-houses, stables, &c. It is a neutral hermaphroditical Salt, being neither a true acid nor alkali, though it is easily convertible to either: it seems partly acid and very volatile, yet partly fixed, and is a great purifier of coarse Metals, and will also destroy and devour them, if not warily and judiciously handled: it is intended further to liquify the fluxes with which Gold, Silver, and Copper are reduced and purged in the assay or crucible; which it does when exposed to the action of fire, in a pure and dry state, and soon flows with those bodies like water; whence it comes to be used in Metallurgy as a flux for those Metals.

Tartar, Argol, is a hard brittle saline substance, with which the sides of wine casks are incrusted; and is red or white, according to the colour of the wine that produces it. An ingenious



author says, "It has Bacchus for its father, fermentation for its mother, and the cask for its matrix." It consists of a peculiar fixed sharp Salt, not improbably inclining to urinous or lixivial Salts. This Salt in Tartar is exceedingly useful in fluxing and depurating some Metals, especially Copper. Tartar also contains a vegetable Sulphur, which is very powerful in reducing and embodying the burnt or vitrified calx of Copper; for which reason, it is justly esteemed the principal ingredient in the assaying that Metal. It is very good likewise, as well as Nitre, for purifying coarse Silver, and for making Silver tough and malleable.

The most imperfect Metals, and the Semi-metals, melt more easily by adding salts to them, than they do of themselves. However, they always lose a great deal of their substance by this means, which happens especially with regard to Copper, whereby an advantage to the buyers of Copper Ore, who smelt in their large furnaces without those devouring and destructive fluxes, must necessarily arise. For if I buy five hundred tons of Copper Ore by a sample of one ounce, which I have tried with some very small loss of Metal by the absorption or rapacity of my saline flux; surely, the amount of Metal which will be saved upon so large a quantity of Ore being smelted without such loss, must be very considerable. Certain it is, that no loss can happen to the buyer who purchases by the produce of his sample; for it is impossible for the sample to yield more Metal than it contains; and the waste upon smelting a large body of Ore, is comparatively small, *cæteris paribus*, to that of the sample.

But, in order to prevent this loss of Metal in some degree, you may add some kind of fat body, that will save it from destruction, and reduce the Metal. The flux proper for this operation is very well prepared by Cramer; and from its colour is there called *Fluxus Niger*, or Black Flux: but we intend to give it as our best reducing flux, according to our own method of preparation, in our chapter upon assaying. Tartar, being burnt alone, in vessels closely shut, or detonated with Nitre, is most quickly alkalized, and thus retains a considerable part of the Oil, which it contains abundantly, and is fixed enough: for this reason, it very easily turns into a reducing flux. This flux, therefore, on account of its alkaline salts, dissolves Earths and Stones, and changes them into an imperfect glass, by a moderate melting fire. But the Oil being of a more fixed nature,



nature, still remains concealed therein, and is requisite both to preserve Metals from being destroyed, and to reduce such as are already destroyed.

Different combinations of the above salts are used by different assay-masters with us, for trying of Copper Ores; but the Black Flux, or the White Flux, (which shall be given hereafter, and which some call their Refining Flux) with careful management, and proper attention to the crucible during the process, will equally answer the purpose notwithstanding the appearance of mystery which our assayers assume.

Rock Salt, or Sal Gem, Sal Fossile, and Common Salt, are all of a mild nature, though they become acid menstrua by distillation. Common Salt is of great utility in the refining of Copper in the assay, because it swims on the matter in fusion; in pouring out of which, the Salt first flows out, and greases the lips of the crucible, if we may use the expression, inasmuch, that the Metal may be poured forth, without sticking to the sides of the vessel. It is likewise useful to prevent the deflagration of the Metal in fusion, which otherwise may be burnt and destroyed; therefore it is always at hand with our assayers to sprinkle into the crucible, when a flame issues from the liquified contents, which it immediately damps and puts out.

Borax, Chrysocola, Gold Solder, may be termed the Gum of Metals, from its usefulness in soldering them. It is a neutral salt, almost insipid to the taste, of a very mild nature, and not corrosive; and though it flows not exceedingly liquid in the fire, yet it makes Metals easily fusible. Its chief intention in assaying, is to sustain and suspend the recements of Metals in their impure scoræ; or to throw such dross upon the surface in a vitrified form; whereby they are purified from their heterogeneous matter. Borax is an artificial depuration from a certain mineral juice called Tincal by the Arabians; and some German authors, say, "That a native Chrysocola or Borax, is dug out of Copper Mines;" but we never knew of its being found with us.

Sandiver, Scoria Vitri, is the fæces and dregs of glass. It is an Alkali, yet seems not void of Sulphur; for an ebullition ensues when it is melted with Nitre, and it is used, though seldom, in assaying of Copper; but it is excellent to collect burnt Silver, and Silver filings, to a body; yet it always makes  
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the Silver foul and brittle, which therefore is further cleansed by melting with the proper reducing flux.

Alga Marina, Kelp, Kali, Fucus, or burnt Ore-weed, contains much salt, of an alkaline quality; as do all sorts of burnt weeds, and Flemish pot-ashes much more, being better prepared. Kelp is the staple commodity of the Scilly-Islands, where great quantities are made in the months of June and July. All those kinds of lixivial salts, are not very corrosive, and are proper in some cases for proving of Copper Ore.

Sal Ammoniack, Sal Arenarius. In former ages, a genuine native Sal Ammoniack was brought from a certain place near the temple of Jupiter Ammon, whence it took its name; and was said to proceed from the urine of camels fed only on green vegetables: but the salt we now have, is factitious from the foot of camels dung burnt; after which it is sublimed into cakes. It is excessively volatile, and is chiefly used in making Aqua Regia, which its distilled volatile spirit serves to mortify, whence it becomes a precipitator of Gold. It is of use also in foldering; and in tinning of Copper and Iron vessels, by making the Tin adhere to them.

Common glass is sometimes useful in trying of Copper Ore; for, in melting, it is of a thick ropy consistence, and therefore serves to entangle and suspend the impurities of the Ore, so that the Metal is better disengaged from its incumbrances and dregs, or purged and separated from its defilements. For these reasons, several sorts of Earths, Spars, and Fluors, with Iron Slags and Ores, may in some cases be serviceable ingredients as fluxes for Copper Ore, by their ropy and absorbent qualities. We know an instance immediately at hand, where the very Slag of Slags is re-melted with impure Copper Ore for those purposes.

Charcoal, Carbo Ligneus, is endued with a vegetable Sulphur, and is therefore often of great consequence for reducing to a body the Ores of Tin, Copper, and Lead, being used as a flux and fuel both. Culm, so called, is the popular flux for assaying of Tin after it is dressed. Pit Coal is entirely improper for any reducing flux.

Thirdly. We come now to speak of Minerals and Metals more particularly; and shall endeavour to distinguish most of them,



them, as they are met with in this county, by their various names and uses. We will here sub-divide Minerals, first, into those of an impure sort or kind, and of no value for Metal; and, secondly, into those which are of use, and yield some produce in fusion, such as Antimony, Calamy, and other Semi-metals. By the first sort of Minerals, we understand all *Cachymixæ*, *Marcasites*, *Pyrites*, or Fire-stones; which several names are well comprehended in the word *Mundick*, whose great Emporium is Cornwall. We shall here but lightly touch upon the natural history of this Mineral Glebe, having already given our thoughts upon some of its properties and useful applications. The figures of *Pyrites* being extremely various, the following are the principal: *Pyrites Idiomorphos*, which is spherical, and hemispherical; in this last form, it is generally found radiated and lamellated, oval, clustered, cristated: angular, consisting of four or six sides; and this last cubical, or tessellated, oblong, rhomboidal, cellular or honey-combed: fistular or piped: all of which are common to Cornwall. (Henckell's *Pyritologia*.)

It may be generally divided into three species, viz. *Marcasita Argentea*, *Aurea*, and *Alba Ponderosior*. It may be also classed under numerous species of *Pyritæ*, such as the *Gymnophyris*, *Pyritrichum*, *Pyritrichiphyllum*, *Pyricubium*, *Pyripolygonium*, *Pyroctogonium*: but as all these names will only serve to confound the bulk of our readers with technical difficulties, it is sufficient to say, that the forms and colours of this Mineral are innumerable.

We find it very plentiful in Lodes of Tin, Copper, and Lead; with which it is so intimately mixed, that it commonly impoverishes the value of each of its companions, notwithstanding every known method is used by fire, water, and various manuductions, to separate and cleanse them from it. Though it is so generally distributed in those Lodes, it does not incorporate with Copper Ore; but is disjunct, yet not entirely separable. But from Tin, its union is sometimes inseparable by water; especially if the Tin is of a lax, sandy, prany, or clayey texture. Its connection with Tin in the hard Stone, is often the same, if the Stone is of a peachy nature, and where the *moleculæ* of both Minerals are equal. In either state it being specifically heavier, no lotions will serve the purpose for disunion, but the most perfect union must be complied with to evaporate part of it, and reduce its ponderosity within the power of future ablutions to carry off: when we come to describe the

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method



method of dressing Tin, we shall explain the process for burning it. After all that can be done, Mundick is such a mortifying inmate, as by its communication corrupts the goodness of the Metal, and renders it harsh, brittle, and ill coloured.

Many are the Lodes of pure solid Mundick, without any mixture of Tin, Copper, or Lead. It may in general be said, that Pyritæ are to be met with in as many different forms and positions, as other Minerals are: such as vein-wise, when the Ore stretches downwards, oftner sloping a little, seldom quite perpendicular. Squat-wise, or in a horizontal position; that is, if not always quite level, yet hanging much, and dipping a little. (The same as a true Lode plot) (Henckell). But as these Lodes of Mundick are not found to produce our Metals, after some little trial they are not deeply enquired into, and are soon relinquished. If they were patiently sunk upon, they might possibly produce Tin or Copper in depth; and it is a general maxim among the Miners, "That a large Lode of Mundick commonly rides a good horse:" indeed, we know several instances of very large Mundick Lodes, answering the pursuit of the concerned with abundance of Copper Ore in depth: from whence many writers have maternalised this Mineral for Copper, which is bastardising the daughter, whose real mother is Gossan; and yet Mundick does partly contain the seed or vitriolick principle of Copper, and therefore it may with propriety be termed the father, and Gossan the mother, or matrix, to fecundate the seed.

Mundick is continually forming concretions; and, perhaps, none of the Fossil kingdom will supply us with more recent and visible proofs of the like activity, in the same short space of time: we think, we have seen it make considerable advances, in three or four years. Poldyfe Mine has lately furnished the curious with many specimens of Crystals of all sizes and shapes; particularly of an hexagonal column, terminated with hexagonal pyramids at both ends, four, six, and eight inches long, to six in the circumference. Some of these Crystals are beautifully correct and clear; others have one or two planes tinged with a brownish ochre, two or three of the planes, both columnar and pyramidal, are granulated with very minute glittering sparkles of Mundick, variegated like the rainbow; the opposite sides are coated half an inch thick, with high blistered incrustations like grapes; others, are totally capped with Mundick at one pyramid, and quite clear at the other; many of them so beautiful



beautiful and splendid, as to exceed the Iris, or the peacock's tail.

In these incrustations, we see the various degrees of approximation of matter sui generis ; and from thence must conclude, that those Pyritæ are modern to the Crystals upon which they are formed, in direct opposition to those Mineralists, who say, all Metals, Minerals, and Fossils, were formed at the creation, as we now find them. “ A circumstance not the least remarkable, is, that Ores are found upon Sinter or Dropstone, in the sides and roofs of old Mines ; a proof of their temporary existence, and that they are not coeval with the world. In short, Mundick is a thing that has grown, still grows at this day, and will continue to grow on Druse, (a honey-combed Stone) so long as the interior parts of this mass of earth are subject to those motions and dissolutions they hitherto have undergone.” (Henckell's Pyritologia). Nevertheless we have met with one of these Coevalists, (otherwise a very sensible man) who insisted upon it, that those Mundick concretions were immediately formed at the creation, upon the Crystal, while it was in a liquefcent state ; and at the same time dense enough to sustain, and support the ponderous Mineral, that it might not fall into, and destroy the geometrical configuration of the Crystal.

We have likewise many specimens of Mundick, which are wholly coated over with Crystal : and a large opaque mass of Crystal, shall contain a very rich piece of Copper Ore in the middle of it, almost totally impervious, till fractured by the sledge. Again, there are large rocks of Copper Ore, sometimes found, in all appearance as if they were solid ; on breaking of which, a cavity is found in them, containing a loose Pyricubium, or exquisitely glossy cube of Mundick. All these are familiar proofs of the doctrine, which we laid down in the first place. Another example whereof, we have in Ilva, an island adjoining unto Tuscany, full of Iron Mines, which when they have dug as hollow and as deep as they can, the circumjacent earth falls in, and fills them up again ; and in the space of fifteen years at most, they work those Mines again, and thence draw out abundance of Metal, which this new earth hath been converted into, and which can be attributed to nothing but to the perpetual accumulation of this and other Minerals, (Alonzo Barba).

Other



Other crude Minerals of no esteem, are those of a ferruginous quality, which the Miners distinguish by the names of Goffan, Cal, (more properly Gal) Cockle, &c. Our Goffan Lodes often produce Tin at a shallow level in tolerable plenty; and chiefly that Goffan which is of the most ferruginous stamina, and we believe from thence denominated Gal, which is old Cornish British, and signifies rust; and being really an inferior Iron Ore, answers in name to its appearance. The Germans call it Wolfram, and define it a kind of Manganese. In this kind of Goffan, after the Tin is separated from all other impurities by repeated ablutions, there remains a quantity of this mineral substance, Gal; which being of equal gravity, cannot be separated from the Tin Ore by water; therefore it impoverishes the Metal, and reduces its value down to eight or nine parts of Metal for twenty of Mineral, which without this brood, so called, might fetch twelve for twenty. Afterwards it is coveted by some of the Smelters, to mix in their large furnaces, where it acts in conjunction with some sorts of Tin as a desirable flux; and increases, though it may depreciate, the lump of Metal.

The general definition of Ochres in Cornwall, may be thus specified: the rusty Ochre of Iron called Goffan; the green and blue Ochres of Copper, Verdigrease; the pale yellow Ochre of Lead, of a Goffan appearance, but like Calamy; the brown and blackish yellow Ochre of Tin, called Goffan, Cal, Gal; and the red Ochre of Bismuth. These Goffans or Ochres, are commonly called the Feeders of their respective Metals; and where they are found, the Metals are generally, and very justly supposed to be not far off.

Cockle (the Skiorl of the Swedes, and the Schorl of the Germans; in English, Shirl) is a brown or blackish glossy stony matter, intermixed with Tin Ore in spots and veins; often shining and resembling the Crystals of Tin Ore, from which by its weight, it cannot be well separated; and in the Stone is not unfrequently mistaken for it, to the disappointment of the Tinner, when it comes to the test of the fire. This Cockle composes a part of the most beautiful charge of our Granite or Moorstone; in which it is so variegated with black and white Talck, that when the sun shines upon it, the beholder is dazzled with its splendour.

Talck, which is the Lapis Specularis, and has the several names of Gold and Silver Talck, Glimmer, Glist, Catsilver, and  
Black



Black Talck, is very plenty in Moorstone as before; but of such small diameter as to be no way valuable, unless in the Stone, for its lucid appearance. There is another sort of Talck common to our Tin veins, a bluish Iron Ore. If Talck gets among Tin, it is a very deceitful brood, as it imitates the colour of the Tin with which it is in conjunction; and when stamped, it preserves its foliaceous laminated form, whereby the water in the buddle slips over its leafy substance; but if it had been more granulated or angular, the water might possibly have more force upon it, and separate it from the Tin, on account of its peculiar levity. In this situation, it is known among the Tinnery, by the name of Clift, Glist, or Glidder. However, Talck and Cockle, seem to be of the foliaceous stony kind, and are mentioned here only as troublesome companions with the Ore of Tin.

Fourthly; Semi-metals. Hill says, "The Tin Mines of Cornwall afford great quantities of Bismuth, though it is very little known there." This is a great mistake; for Bismuth is very well known here, and our Tin Mines never yet afforded any quantity worth the saving. That we have Lodes of Bismuth, and those of Cobalt and Bismuth together, is very true; but hitherto of little worth. According to the opinion of foreigners, no place exceeds Cornwall for variety and plenty of Minerals. "Beecherus refert de Cornubia, in dedicatione alphabeti sui Mineralis, se credere nullum terrarum locum reperiri, qui minerarum multitudine et varietate antecellat." This shews how great reason we have to lament our ignorance in the examen of other Minerals beside those which produce Metal. If those of our county, who have leisure and ability to look into the contents and properties of our various Fossils, would employ their talents for that purpose, we should not long remain in our present darkness; a little time would bring to our knowledge the value and usefulness of much neglected treasure. Even ignorant pretenders to chymical operations, might in time blunder out some curious discoveries; and accident might effect, what prudence may not accomplish. Unfortunately for us, none pry into the concealed contents of our numerous Fossils; for the attention of the natives is principally engrossed by Tin and Copper.

Bismuth in the state of Ore, is usually of a bright silvery white, and of an obscurely and irregularly foliaceous structure. Sometimes it appears granulated; and at others, the granules are large, and the masses coarse; in which case, every separate  
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granule



granule appears of a cubick form. It is subject to fewer variations in its Ore, than most other Minerals; but is sometimes turned yellow by an over proportion of Sulphur; and sometimes is very deeply tinged with the matter of common Mundick, and is often mistaken for it. (Kunkel, Boerhaave).

It is easily separable from its Ore, and may be made pure by merely melting the Ore alone in a crucible in a moderate fire: when it is in a more impure state, it is procured by an addition of the reducing flux before mentioned; but if the fire be too fierce, the Bismuth will be lost.

A small portion of Bismuth increases the brightness, hardness, and sonorousness of Tin. The uses of Bismuth are, for making Pewter with Tin; for soldering some Metals; for printers types; foils for mirrors; for anatomical injections; for imitating Silver on Wood; for purifying Gold and Silver by cupellation; and for rendering some Metals fitter for being cast into moulds, as it increases their fusibility.

Zinc; the Ore of which is Lapis Calaminaris. Great quantities of Tutenag were till lately imported from the East-Indies; but the late Dr. Isaac Lawson observing, that the flowers of Lapis Calaminaris were the same as those of Zinc, and that its effects on Copper were also the same with that Semi-metal, never remitted his endeavours, till he found the method of separating pure Zinc from that Ore. Cadmia, or Lapis Calaminaris, is a spongy substance, of a lax and cavernous texture, yet considerably heavy. It is found in masses of various and irregular figures, with rugged and uneven protuberant surfaces. When most pure and perfect, it is of a pale brownish gray colour; but its lax and spongy textures, make it very liable to be fouled by extraneous matter, and thence it is often found yellow or reddish. It is moderately hard, but will not give fire with Steel; it will not effervesce with Aqua Fortis; and it calcines in a small fire to a pale red. In fact, the Ochre of it is a Gossan; and though the above descript is the true and genuine Mineral of Zinc, yet that Semi-metal is not confined to that Ore alone, but is mixed in great abundance in its disseminated particles among the matter of the Ores of other Metals, particularly of Lead.

Mock Lead, Black Jack, and Blende of the Germans, is really a contaminated Zinc Ore, (and some of it even very little so)



so) and would answer every purpose of it, if it was not in general so united to the principles of Iron and Arsenick. It is the most plentiful Mineral we have next to Mundick, and has of itself distinct Lodes; but it is most commonly mixed with Mundick in some of our Copper Lodes, before they are wrought to any great depth. It has been much used for the making of Brasses, instead of Calamy: several ladings have been shipped off for that purpose, at the price of forty shillings down to a moidore  $\text{£}$  ton; which might pay for the dressing of it, as the Burrows, or heaps of refuse in some Copper Mine Bals, will supply great quantities of it.

To extract the Zinc, the Calamy must be finely pulverized, and well mixed with one eighth part of charcoal dust, and put into a close retort, to prevent the access of air, which would inflame the Zinc as it rises. The retort is to be placed on a violent fire, sufficient to melt Copper. After some time, the Zinc rises, and appears in the form of metallick drops within the neck of the retort, which, when cool, you break to take out the Zinc.

Lapis Calaminaris with Copper, makes Brasses; Zinc with Copper, makes Princes Metal, or Bath Metal; and improves Tin in whiteness and hardness, in the composition of some Pewter.

Stibium. Antimony. This Semi-metal in its Mineral Ore, is of a dark lead colour, staining the hands black; and is generally full of long shining needle-like striæ; though often of an exceeding small close grained texture, hard, brittle, and very heavy. It is found in different parts of Europe, as Bohemia, Saxony, Transilvania, France, and even in England in some considerable quantities, though as far as we yet know, confined to the counties of Cornwall, Devon, and Somerset; from the north-west quarter of the latter, only a few specimens; from different parts of Devon some tons; and formerly from Cornwall, in quantities of twenty, and even thirty tons. In the last three years this county has produced about one hundred and twenty tons from one Mine called Huel Boys, in the parish of Endelian; viz. in the year 1774, nineteen tons, at  $\text{£} . 13$   $\text{£}$  ton; in 1775, forty tons, at  $\text{£} . 13$  10; and, in 1776, thirty-six tons, at  $\text{£} . 14$  14  $\text{£}$  ton. The expence of getting this Antimony, exclusive of driving an adit to the Mine, has been less than one third of the amount of its produce. The remainder



remainder of the one hundred and twenty tons above mentioned, is chiefly the product of a Mine near Saltash, belonging to Mr. Thomas Reed and partners.

The direction of the antimonial veins, is mostly from north to south; but there are now and then some small quantities found in veins which run different courses, and which, from their superior product of other Minerals, are denominated according as the different Metals predominate. Antimony lies in its veins or Lodes extremely unequal, but generally more so length-wise than in depth. It is not uncommon to have the vein two or three feet wide, and in driving as many, not only the Mineral, but even the vein itself will be scarce perceptible. We have not known any of this Mineral wrought more than fourteen fathoms deep. The Mine of Huel Boys above mentioned is about twelve fathoms, and in the bottom promises continuance.

Foreign Antimony does not come to us in the state of its Ore, but what is, however, called Crude Antimony; which is obtained from its earthy and more stubborn mineral particles, by a kind of eliquation, in the following manner. The Mineral is put into earthen pots pierced in their bottoms with small holes; these pots are placed in a furnace, where they receive the necessary heat for the fusion of the Antimony; but much less than is sufficient to fuse any other of its mixtures, except Lead, with which it is often combined, and which even this fusion will be sufficient to melt with it into the same mass. For this reason, Crude Antimony used medicinally should undergo an examination, to discover whether it has Lead in it; as I am informed it may have a considerable quantity without altering its striated texture, and for which reason I am inclined to believe, that English Antimony is the least proper for medicinal use, as it is more liable than Foreign to a saturnine mixture. This Crude Antimony comes to us in the form of the pots or moulds in which it has been melted. Some of the Antimonial Ores of this county, without any such preparatory fusion, have been found to produce at least as large a quantity of Regulus, and equally fine, as the best Foreign Crude; and as they generally lie very rich in the earth, this fusion is mostly rendered unnecessary.

Mr. Reed has erected furnaces in Feock parish, on Restronguet river, for extracting its Metal, commonly called Regulus of Antimony; which is performed by mixing the clippings of the  
the



the Tin-Plate Workers with the Mineral Ore, first well cleansed from its stony earthy parts, and smelting this mixture in pots containing from a half hundred, to one hundred weight: in which operation the reguline part of the Antimony, freed from its Sulphur, by the latter's uniting with the Iron in the before-mentioned clippings, by its superior gravity sinks to the bottom of the pot, leaving the other parts in a light mineral-like scoria on the top, which readily separates when cold. The foreign Ores of Antimony are melted in London, for these purposes, in the same manner; only Mr. Reed's is done in an air furnace, and in London they use the bellows as in other small founderies. The use of the clippings is for the sake of cheapness and convenience, for a somewhat less quantity of small Iron alone will effect the precipitation. Regulus of Antimony may also be obtained by substituting, for the Iron, Copper, Lead, or Tin; but these must be added in a much greater quantity, and the operation consequently will be attended with much more expence, and greater difficulty, and are, therefore, substituted only on very particular occasions. The greatest consumptions of Antimony, besides the medicinal, are made by mixing its Regulus with Tin to make Pewter hard and sonorous; and with Lead, &c. for Printing Types; though it has several other uses.

Cobalt, is a dense compact and ponderous Mineral; very bright and shining, and much resembling some of the Antimonial Ores. It is sometimes found of a deep, dusky, bluish black; very heavy and hard, and of a granulated structure, looking like a piece of pure Iron where fresh broken: at other times it is found more compact and heavy, and of a very even texture, not granulated or composed of any separate Moleculæ, but resembling a dusky mass of melted Lead on the surface, and will bear to be cut with the knife. The inner part, where it is always very bright when fresh broken or cut, is also found, in some places, in a much more beautiful appearance than either of these, being of a fine bright silver gray, and of a beautiful striated texture, the striæ running all great lengths, but very slender and variously bent, undulated, and in some parts broken. It is also sometimes soft, and covered with a bluish coloured efflorescence, which is generally rich in Regulus.

We have given our thoughts upon the subject of Arsenick, and suggested that it may be cheaply rendered by our Mundick sublimations, after the manner in which it is procured from



Cobalt; and the more we look into, and consider the operations whereby Arsenick, Zaffre, and Smalt, are obtained from this Mineral, the more we are convinced, that a skilful hand may improve upon the hint in relation to the different sorts of our repudiated Mundick.

We have had but one Cobalt Mine that ever was distinguished by that name in this vicinity, which was discovered accidentally by Mr. Beauchamp, in an adit that he drove through some part of his estate at Pengreep in Gwenap. He discovered a Lode of three feet breadth, which contained a branch of real Cobalt; and it happening about the time when the Society of Arts, &c. offered a premium of thirty guineas for the best Cobalt to be discovered in England, he was honoured with the reward for his specimen, pursuant to the advertisement. It did not hold in depth, but soon deserted the pursuers; who were likewise very soon after obliged to suspend their search, by a prodigious influx of water to their workings.

At Huel Trugo also, a Copper Mine near St. Columb, some of the purest Cobalt has been worked. It was in a small vein, four to six inches big, in which there were no other mixtures. It crossed the Copper Lode, which was pretty large, though not rich; and the Cobalt lay in the vein just where it joined the other, but did not hold to any length, so as to make it worth pursuing. It was very fine, and supposed by some who think they know the value of it, to be worth more than sixty pounds per ton. It was of a pale red, or rather blossom colour; and, on being exposed to the air for any considerable time, the surface was covered with a farinaceous substance resembling the sublimite of Arsenick, which it probably was; but lest the fine colour should evaporate, the proprietor, Mr. Champion, ordered it to be put into casks filled up with water. The common air was, or seemed to be, the menstruum, which dissolved the surface of this Mineral, which it is probable in process of time, as it became longer exposed to it, would have totally crumbled into that floury substance. Cobalt is also supposed to be in no small quantity in Dol-Côth Copper Mine, for the assayers generally find their pots tinged with blue; yet it seems to be so blended with Copper and Iron that it does not discover itself in a mineral state, being probably but in the general term of Mundick. Very good Cobalt has also been discovered in Dudnan's Mine in Illogan parish; and in a Mine wrought for Tin and Gal near Pons-Nooth in Perran-Arwothall.

In



In the last place, we come to define Metals only, which we shall presume to be such on the respective principles of their ductility and gravity. Their malleability may arise from the figure of their parts, perhaps oblong or square, which may occasion their cohering so strongly, as not easily to be separated; and it is probable, the pores of their constituent particles, or of the whole mass, are few and small; which may account for their being so much heavier than any other bodies. The radical characters of Metals stand thus: the weight of Gold to that of Glass, is as 9 to 1; and the weight of Tin, the lightest of all Metals, is to that of Gold, as 7 to 19: which considerably surpasses the weight of all Stones, and other the most solid bodies. The specifick weight of the several Metals, and of Granate, Water, and Air, stands thus:

|             |        |         |                |
|-------------|--------|---------|----------------|
| Gold        | 19,636 | Copper  | 8,843          |
| Platina     | 17,000 | Iron    | 7,852          |
| Quicksilver | 14,019 | Tin     | 7,321          |
| Lead        | 11,345 | Granate | 3,978          |
| Silver      | 10,535 | Water   | 1,000          |
|             |        | Air     | $\frac{3}{11}$ |

Formerly there were but six Metals so denominated, to which by some was added Quicksilver, which has every property of Metal except fixidity. To these we shall add another original Metal lately discovered in the Spanish West-Indies, and by the Spaniards called Platina, from its resemblance in colour to Silver, from which it would not be so well distinguished, but by its superiour gravity, and inferiour ductility; which particularities are extremely remarkable.

Gold, by the ancients, was characterized the sun, which they imagined did influence and produce it. Gold is very rarely seen in a state of Ore; being of all Metals most frequently found native. It is a general opinion, that it never was found in a mineral state, but always pure and metallick: I have, however, seen, in the possession of that curious investigator of natural productions, Dr. Hunter, a large specimen of mineralized Gold, which the doctor had from Germany: one point of it was pure Metal and Quartz; and the other, I confess, had all the appearance of a mineralized Gold Ore.

Gold is free from Sulphur and Arsenick; has no certain figure; and is found pure in Flint, white Quartz, or debased Crystal.



Crystal. It is seen in Lapis Lazuli, and some of our pebbly stream Tin. It is not uncommon to meet with Grains of solid Gold in our stream works; and some large pure lumps have been met with in those works for Tin Ore, of which the late William Lemon, Esq; grandfather of the present Sir William Lemon, Bart. had one that weighed fifteen penny-weights and sixteen grains. That there were such grains, called Corns of Gold, formerly observed in stream Tin, we have the authority of Mr. Carew, fol. 7; and in the Bayliff of Blackmoor, a M. S. in my possession, written by one Mr. Beare in queen Elizabeth's time, there is an account of a gentleman, "who at a wash of  
 " Tin, at Castle-Park near Loftwithiel, took up out of the  
 " heap of Tin certain fine Corns, Hops, or Grains of Gold,  
 " which they called Rux; and at the same time, shewed a  
 " Gold ring on his finger, made of certain Gold, which he had  
 " gathered out of the Tin at a wash in a stream work, together  
 " with another Gold ring, each of sixteen shillings and eight  
 " pence value." He likewise tells us of "two blocks of Tin,  
 " carried by one Mr. Robert Davy to Bourdeaux, which were  
 " by two Florentine merchants valued to be worth all the rest  
 " of the Tin there, by reason of the Gold contained in them."

The late William Glynn, Esq; grandfather of the present learned recorder of London, had a large Gold seal ring, made of Gold found in the river under his house at Glynnford. Whether the great Mr. Boyle had heard of these facts, or that it was a notion of his own, it is most certain, that he imagined a good quantity of Gold might be extracted out of Tin, without prejudicing the Metal; and to that purpose, sent down Christopher Kirby, Esq; (well known for having been unhappily drawn in by Dr. Oates to countenance his plot) to make some experiments therein, in the latter part of the reign of king Charles the second. But in a few months after king James came to the crown, Mr. Kirby being apprehensive of some ill usage on account of Oates, fled into Holland, from whence he returned with the prince of Orange; and Mr. Boyle's death happening much about the same time, this project fell to the ground.

Of all Metals, Gold is easiest to be amalgamated with Quick-silver; so that a Gold ring being a little touched with it, will be no longer useful to the owner if the Quicksilver is not speedily burnt off in a strong fire. It is dissolvable in Aqua Regia; but a true Aqua Fortis makes no impression on it; for if you put into it a piece of gilt Silver wire, whose Silver is half  
 a grain,



a grain, and the Gold but one ninety-sixth of a grain, drawn into the length of an ell, the Silver will be eaten out, and a tube of Gold shall remain, which, notwithstanding its extreme thinness, will be still opaque. The ductility of Gold is beyond all imagination. By exact weighing and computation it has been found, that there are Gold leaves, which, in some parts of them, are scarce the three hundred and sixty thousandth part of an inch thick; yet, with this amazing thinness, are still a perfect cover for Silver wire; nor can the best microscope discover the least chasm or discontinuity to admit any known fluid, or even light itself: but this depends altogether (incomprehensible as it is) on its being free from Sulphur; for mix but one grain of Sulphur with a thousand of Gold, and it is malleable no longer. Neuman says, "A single grain of Tin added to the foregoing proportion of Gold, will have the same effect;" which, we suppose, must be owing to the Arsenick that is concealed in the Tin. Yet Antimony, which contains much Sulphur, purifies it exceedingly well, and, by absorbing and destroying all its heterogeneous associates, promotes its liquefaction.

Although Gold has so great a specific gravity and solidity, yet its interstices and pores are found to be much larger than those of Silver, but not near so numerous. Fine Gold is so very perfect and durable, that it is never injured by lying in the ground for thousands of years; nor will any fire vitrify or destroy it in a common natural fusion: yet by exposing it to the rays of the sun, in the focus of a peculiar large lens or burning glass, it melts; and being sufficiently continued thus in fusion or calcination, it emits a fume, and becomes a ponderous glassy substance or scoria of a purple colour. [Doubtful]

To render this Metal more hard than it naturally is, they alloy it with Silver or Copper; yet it cannot bear to be mixed with Brass, which makes it brittle, by means of the Calamy.

Platina is found, not in Ore but in small grains; yet not pure, but mixt with a shining black sand: there are likewise usually mixt with it, a few shining particles of a golden colour. When exposed to the fire by itself, it is extremely hard to melt; but fuses readily with Gold, Silver, Copper, Lead, or Tin, and incorporates with them. A piece of it was put into strong Aqua Fortis, and kept in a sand heat for twelve hours, but



when taken out, was no way corroded, and it preserved its first weight. It appears then, that no body comes so near Gold, in fixedness and solidity. Cronstedt says, it is heavier than Gold; and therefore the heaviest of all bodies hitherto discovered: for though the specifick gravity of Platina, in the hydrostatical experiments made by Dr. Lewis, is found to be, to water, only as 17,000 to 1,000; yet, when melted with other certain Metals, its specifick gravity has, by an exact calculation, been found to be considerably augmented, even so much as to 22,000. If it could be made as ductile as Gold, it would not easily be distinguishable from it by its other properties. It entirely resists the vitriolick acid, which dissolves or corrodes every other known metallick body, except Gold; yet it differs from Gold, in giving no stain to the solid parts of animals, nor striking a purple colour with Tin: it is, therefore, a simple Metal, of a particular kind, essentially different from all those hitherto known. Platina hardens and stiffens all Metals; one more than another, but Lead the most. Tin bears much the least, and Gold and Silver the greatest quantity, without the loss of their malleability. Though it is of an uniform texture, bright and shining per se, takes a fine polish, and does not tarnish or rust; yet it makes Tin tarnish soon, and Lead very quickly.

The sciences, commerce, and arts, must receive great advantages from the application of a new perfect Metal to useful purposes; which, to the fixidity and indestructibility of Gold, unites a hardness and solidity almost equal to those of Iron. We regret, that although large quantities of it are found in America, it is here so exceedingly rare.

The cause of the great scarcity of Platina is, that the Spanish ministry have prohibited the sale of it, or the extraction of it from the Mines. These prohibitions were certainly from good motives and wise intentions; for this Metal was no sooner known than it was employed for the adulteration of Gold, for which purpose it is very fit, as it sustains all the ordinary trials of Gold, has the same specifick gravity, and renders Gold much less pale than Silver. The use of a Metal, with which frauds so prejudicial might be committed with impunity, was necessarily interdicted: but since the best chymists in Europe have examined Platina, they have published certain and easy methods by which the smallest quantity of Platina mixed with Gold may be discovered, and by which these Metals may be separated in whatever



whatever proportion they may happen to be united. These methods may be seen in the memoirs of the chymists, who have examined this matter. We shall here only relate one of the most convenient and less troublesome. It is founded on a property, which Gold has, and Platina has not, of being capable of precipitation from Aqua Regia by martial Vitriol; and upon a property which Platina has, and Gold has not, of being capable of precipitation from Aqua Regia by Sal Ammoniack. When, therefore, we would discover whether Gold be allayed with Platina, let it be dissolved in Aqua Regia, and in this solution, which will contain both Metals, let some Sal Ammoniack dissolved in water be added, and the Platina will be precipitated in form of a brick coloured sediment. If on the other side, we would know whether Platina contained any Gold; let this Platina be dissolved in Aqua Regia; and to the solution, add a solution of martial Vitriol in water, upon which the liquor will become turbid, and the Gold will form a precipitate, which may be easily separated by decanting and filtrating the liquor. We may then affirm, that the reasons which induced the Spanish ministry to interdict the use of Platina, no longer exist; and we hope, that when they are once convinced of this, the publick will be no longer deprived of a substance which may be so advantageous to society. Dictionary of Chymistry.

Quicksilver, Mercury; which names it seems to claim from its relative velocity to the god Mercury, as well as the planet. This Metal, if it really can deserve that name, is almost simple as element, when in a fluid purified state. It is sometimes found in that form, and is reckoned preferable to that which is procured from the Ore of it, called Cinnabar. Mercury will amalgamate with all Metals, except Iron; and is, therefore, sometimes adulterated with Lead or Tin, because of their cheapness.

The detection of such frauds is of great consequence to the medicinal use of Mercury; and, therefore, that which is of a livid or pale colour, any way resembling powder, and runs into globules not exactly spherical, but oblong like little worms or tears, ought to be rejected. A very minute quantity of Lead largely diluted, we are told by Dr. Baker, is of pernicious and fatal consequences to some of those who take it into their bodies; insomuch as to have given name to a particular disorder in these parts, called the Colick of the Dunmonii, which was endemial in Cornwall and Devon in the year 1742, and returns every  
autumn



autumn more or less. I have met with those who have been tortured with this excruciating and uncommon disorder, which, though seldom mortal as a Colick, leaves behind it a spasmodick Asthma, and an incurable Paresis. All this is occasioned by a few grains of Lead dissolved in the cyder which is made in leaden vessels. If Mercury thus stored with Lead is taken into the human body, what is to be expected but that we may introduce the greater enemy to expel the lesser. To release the impure mixture with Quicksilver, you may rub a little of it in a marble mortar with some vinegar: if the acid becomes a little sweetish, Lead is certainly mixed with the Mercury; if the vinegar is tinged, some other Metal is to be suspected; but it is quite pure, when a little of it, held over the fire in an Iron ladle, totally evaporates. It remains to be remarked, however, that Quicksilver dissolves in all fossil acids. There is scarce any cohesion at all in the parts of Mercury; for a single grain thereof, by the action of a lens, is divisible into millions of globules invisible to the best eye; but by the application of a microscope, they will afford a distinct prospect of all the neighbouring objects. This incoherence of Quicksilver is the reason why it is so extremely volatile as to rise in a fume by the action of a very small fire; but being mixed with Brimstone, it embraces it most tenaciously: and may then be reverberated by a great degree of fire, till it becomes such a red substance, as is sold in the shops by the name of Factitious Cinnabar, or Vermillion.

We have no records to inform us that Quicksilver was ever found in this county; but why this fertile Mineral district should be exempt from the production of it, is no way clear: perhaps it might be found, if proper diligence and observation were used to get at it; though indeed if it was supposed to be in any uncommon Stone of a red or gray colour, the common method of assaying would only serve to send it up the chimney in an invisible fume, which ought to be saved in close vessels.

The chief Mines for Mercury are these of Hungary, Spain, Friuli, and Peru. A Mine in Friuli is so rich, that it always yields one half Quicksilver, sometimes two-thirds. The miserable slaves condemned to work in those Mines, are affected with tremors, and proceed to salivate; then their teeth drop out; and they are seized with pains all over, especially in their bones, which the Mercury penetrates; and thus they die. A common precaution they use is, to hold a piece of Gold in their mouth to imbibe the effluvia and intercept their passage into the body.

Dr.



Dr. Pope tells us of one he saw in the Mines of Friuli, who in half a year's time was so impregnated with the Metal, that on putting a piece of Brass in his mouth, or even rubbing it in his fingers, it would turn white as Silver. Nor can this be wondered at, since it has been known to amalgamate the Gold earrings of the salivated wearer; and I have myself seen very minute globules in the rotten processes of some bones, when I dissected under the instructions of the accurate Dr. Hunter. *Non semel in sepulchris argentum vivum capitibus reperi.* Anton. Musa Brasavolus, in tract. de morb. Gallic.

Lead, Plumbum; also Plumbum Nigrum, to distinguish it from the Plumbum Album or White Lead, which was the name given by Pliny to Tin, although it is radically a distinct Metal. It is stiled Saturn, from the Planet of that name. It is seldom found malleable and purely metallick; for what have been taken for specimens of native Lead, have produced, very often, three parts in four of fine Silver; from whence many have supposed, that there is no such thing as native Lead: I have however seen two specimens of it, in the possession of Mr. Bennallack in this county.

This Metal seems to consist in part of an impure leprous earth, of a sulphureous nature; and it abounds also with something very acid and corrosive, though cold, and causing paralytick complaints in those who are much concerned in the melting of it. It may be dissolved in many sorts of weak acid menstrea, much better than in those of the greatest strength; and it will incorporate indifferently well with Quicksilver; but does not admit of ignition, for it melts in a very small degree of heat.

The only Lead Ores which we have seen in Cornwall, are these four sorts: first, the lead coloured bluish gray, of no particular form; secondly, the Antimoniated striated glittering Ore; thirdly, the steel grained; and lastly, the tessellated or diced Lead: most of which are so extremely rich both for Silver and Lead, as to be well worth the working, if the Cornish Lead Lodes were of a larger size, and more lasting than they generally are. The small profits arising from this Metal hitherto wrought with us, have damped the ardour of our adventurers in their pursuit of it; and the Lead which has been discovered in the west of the county, has for the most part offered itself accidentally, when the Miners have been searching for Copper, with which it is more generally associated than with Tin. For my



own part, I have never seen it blended with Tin; but with Copper frequently; and always very rich for Silver, but in no quantity. Black Jack and Mundick are very close companions with it; but they, and Copper Ore, are all of them distinct and discernible from each other, in the Stone or Mineral state. In searching for Copper Ore in Nanskuke Downs, in a very promising Gossan, we discovered a leader, six inches wide, of very rich Lead of the Antimoniated kind upon the north wall of the Lode. The Silver in it was plenty, insomuch as to render the Mineral worth £.18 or £.20  $\frac{1}{2}$  ton without any dressing. It produced about a ton and half, and then totally disappeared.

It is a mistake of those who think that Lead becomes brittle by extracting the Silver from it, for it is rather more ductile. The deleterious properties of Lead I have already hinted at, in treating of Quicksilver; and I may observe in this place, that any saturnine preparation given inwardly, must be very hazardous, unless administered under the direction of a skilful practitioner.

In degree next to our provincial Metal, Tin, this island has been famous in the annals of past ages for its peculiar production of Lead; and the kingdom in general has been more remarkable for the quantity produced, insomuch that Pliny saith, “In Britain it runneth ebb in the uppermost coat of the ground, and that in such abundance, that, by an express act among the islanders themselves, it is not lawful to dig and gather Ore above such a proportion set down by stint.” And Sir Joshua Child, in his discourse of Trade, tells us, “That our Lead and Tin, which are natives, and by God’s blessing inseparably annexed to this kingdom, carry on much of our trade to Turkey, Italy, Spain, and Portugal; besides great quantities that are sold to Holland, to France, and to the Indies, as is well known to all the merchants that trade to those parts.”

We have had many ancient Mines of Lead in Cornwall, particularly in Perran Zabulo; the Garres in St. Allen; and elsewhere. It is said that the wars in France were carried on by the Silver of those and the Devonshire Mines. The Ore in the Garres, when last wrought about sixty years since, was so rich in Silver, as to yield one hundred ounces to one ton of Lead.

When the Miners have been searching for Copper, with Silver, it is more generally associated than with Tin. For my own



Silver, Argentum, C Luna, from its attributed planet. Of all Metals, Gold excepted, this Metal is found most frequently native; and it is, indeed, found in that state, more commonly than in Ore; and if you break the stony Glebe or Mineral, you will sometimes find solid grains and lumps of malleable Silver contained in them. Silver is usually mixed with other Metals, particularly in Cornwall with Copper and Lead, though but in a scattered form and minute quantity, in the former no way adequate to the expence of extracting it.

Real Silver Mines distinct from any mixture with other Minerals, we have none in England. We read of such, but they give us no produce to value ourselves upon them; and indeed the two nobler Metals are foreign to our country, at the same time the base and more useful Metals are bestowed upon us in common with the rest of the world. In our kingdom of Danmonii Silver Mines were discovered in Edward the first's time, when 337 men were brought from the peak in Derbyshire to work them. Edward the third had great profits from them; and queen Elizabeth presented a cup made of Silver to the earl of Bath, with an inscription upon it, from which inscription we must conclude, that those Silver Mines, so called, were absolutely Lead Mines rich with Silver.

In Sweden they have a Silver Mine 150 fathoms deep, of which they have no records so ancient as the first discovery of it; yet we do not apprehend it is a very profitable concern: neither are there any very rich Silver Mines in Denmark, although there is preserved, in the Royal Museum at Copenhagen, a piece of native Silver five hundred and sixty pounds weight, with three other specimens, above three and two hundred weight in each. There are likewise some considerable Silver Mines in Hungary; but none in Europe, it is likely, of a produce equal to the Hanoverian Mines, some of which are worked at the charge of our most gracious sovereign, and others let out to farm to his private and great emolument. I presume the single Mine of Potosi in Peru, has exceeded every other quarter of the globe, in the richness and quantity of this valuable Metal. From this great vein, which is about six feet wide, do issue out some small sprigs of little account, and yet here they refine thirty-eight millions five hundred thousand pounds weight of Silver yearly; one pound of their Ore yielding one ounce of fine Silver, at which rate, they must raise yearly two hundred fifty-six thousand, two hundred and fifty tons of Ore, before they can answer that account



account in Silver : but by Gerard Molino's account, they must raise a great deal more. The vein runs directly north and south, sloping, hadeing, or underlying, in the hill towards the east. They have an adit or level, which they were twenty-two years driving ; but they do not discharge their Ore through it as formerly, because it is become very long and crooked ; therefore they carry up their Ore on their backs, each slave about fifty pounds weight in wallets, on ladders made of ox-hides, three and three in a row, one of them having a candle tied to his right thumb, to light the rest. This work employs above twenty thousand Miners, and is wrought day and night above a thousand yards deep (see Acofta in his Natural History of the Indies) : and several merchants that have travelled into those parts relate, that this mountain, by reason of the numerous smelting houses upon it, looks at a distance as if it were all on fire. (Waller on the Mines of Sir Carbery Price).

Cramer allows but four sorts of Silver Ores, fundamentally such ; others being only impregnations of that Metal with foreign Minerals. The first is a vitrean Ore of an irregular figure, sulphureous, and of a lead colour : the second is a horny Silver Ore, semi transparent, like rosin in colour, of no external figure, but closely examined it consists of very thin plates : the third is a red or scarlet Ore : and the fourth is of a light gray colour : and even this contains more Copper than Silver, even so as scarcely to deserve the name of Silver Ore. Oftentimes Silver is found, like Wire, woven one within the other, between the rocks ; and sometimes it will resemble Lace, by the Spaniards called Metal Machacada, which, from its description, I apprehend to be like our native Filagree Copper.

Silver readily amalgamates with Mercury, and is easily dissolved in genuine Aqua Fortis ; but will not yield to Aqua Regalis, nor any other water impregnated with Sal Gem, Marine Salt, or Sal Ammoniack : these kinds of Salts, or their distilled waters, may serve to precipitate a dissolution of Silver from Aqua Fortis, only for this ill consequence, that Silver thus precipitated becomes very harsh and stubborn for fusion, and is also rendered partly volatile, so that it evaporates considerably in the fire : this is that precipitation of Silver, which the modern Chymists call Cornua Lunæ. This Metal per se, is so soft, that it is expedient to allay it with Copper or Brass to fit it for use.

Copper,



Copper, Venus, or Meretrix Publica; a common prostitute from its reception of all menstrua, other Metals having their peculiar dissolvents. The acid particles of air will readily dissolve Copper, and shew itself by an ærugo or rust upon the Metal. Oils themselves dissolve Copper by means of a Salt contained in them; for even the ends of tallow candles which the Miners leave under-ground, if touched by any cupreous water, will presently be tinged green. This solubility is so extreme, that a single grain dissolved in spirit of Sal Ammoniack, will give a blue colour to 256,806 times its own bulk of clean water; and a faint, yet discernible one, to above 530,620 times its bulk. Copper in fusion, will not bear the least drop of water; for if the moulds be wet, it flies into numerous particles, like shot from a gun; and may destroy the persons near it, of which I once met with a dismal instance in one of the workmen at Hayle Copper-house.

Native Copper is frequently found in our Mines, near the day or surface, or commonly but a few fathoms deep; though there are some few instances of its being found very deep, particularly in the Mine of Cooks Kitchen, from whence several tons have been sold to the Cornish Copper Company, for immediate fusion, as it came out of the earth.

On the side of a rivulet, ten leagues to the south of Lake Superior in North America, there is a single lump of native Copper, about four tons weight, free from any mixture but a few small black Stones of an Iron nature, and some very fine grains of Crystal. Lake Superior, north from this lump of native Metal, is very wide. No vein of Copper was discovered on the south side of the Lake, near this lump; but some few very small ones on the north side, not worth the pursuit. This I had from two credible Miners of Redruth, who were sent over to make discoveries in consequence of this singular appearance.

We have before observed, that Copper is the most easily dissolved of any Metal, even by common water; but certainly the dissolution must be quicker, if that water is charged with acid or alkaline principles. Wherever Copper is found, there is always green or blue Vitriol, which are soluble and easily mix with every moisture. The action of these principles, will, pursuant to their relative strength, dissolve and defecate the Copper particles they meet with, from their impure and heterogeneous admixtures; and keep them suspended, till they are

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arrested by the magnetick nidus of Goffan, when it is variously deposited, Stalactical, Guttatim, Machacada, or otherwise, as we may judge from the pressure, form, and situation of it when found.

The Stalactical, is generally of a brassy colour; and so is the blistered buttony Ore, which is protuberant in a semi-circular form, occasioned by its descent guttatim, into a soft and yielding bed of clay. But the vitriolick solution that forms malleable Copper, is the strongest that can be obtained; therefore it is the more readily attracted by the ferruginous particles of the Goffan through which it percolates, and in very little time, assumes the place and form of its magnet, in quantity, *cæteris paribus*, as the solution and the nidus are more or less abundant. Being thus situated and circumstanced, it likewise forms the Filagree, Laced, Machacada Copper of Alonzo Barba; which is the precipitation of Copper on the laminæ of Goffan, intersecting in all directions, and leaving unequal cavities, of various angles between the septa: the structure, therefore, is very cellular, and makes it look like copper lace that has been burnt.

These three sorts, however, are very scarce; and more of them are saved for the cabinets of the curious, than are melted in the furnace. Green Copper Ore is likewise very rare in Cornwall; and is seldom so pure, as to be taken for a gem of the Turkois kind. Blue Copper is seldom met with, and in esteem only among the curious.

Gray Copper Ore is one of the richest sorts in this county. It looks like a kind of Lead; cuts with a knife, to a very smooth face; and will produce the greatest quantity of Metal, of any Copper Ore.

Black Copper Ore, of a bluish black, is also very rich. This is either solid, or sandy, being mixed with a light tender Crystal and sandy Mundick. It is so light, that it will not bear the usual dressing by water; but is generally griddled out and put to the pile for sale, as it rises from the Mine. Being in this condition, it partakes of Mundick, Goffan, Earth, and Crystal, so largely, that the intrinsic value of the Ore will be carried off with it. It is said, that formerly several thousand pounds worth of this Ore was thus washed into the rivers, and discharged into the north sea from the old Pool Mine. This kind of Ore in the Lode is oftentimes so fair, that it may be raised  
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and dressed fit for smelting, at the rate of a shilling out of the pound, in the price it sells for; nay I have known an instance of its being done for ten pence. In this case, the end or stool of the vein will run of itself, like sand, against the workman with the use of his shovel only. This Ore generally lies shallow; and seventy years ago, when Copper was not searched for and little known among us, the Tanners threw it into the rivers as refuse, by the name of Poder, which signifies dust, Mundick, or waste. After it became well known, and was wrought for sale, it seldom exceeded £3 10s.  $\text{per}$  ton for several years, while there were but one or two purchasers.

Red Copper Ore is rather scarce, but it is valuable. There is a kind of red, steel grained, gossany Ore, that looks very rich, and is worth from £14 to £20  $\text{per}$  ton, according as it is impregnated with Gal or Iron, which renders it harsh and stubborn for smelting. But of all Copper Ores, that which goes by the name of Peacock Ore, far surpasses the rest for beauty and elegance of tint, while it is new and fresh; for after it has been long exposed to the salts of the atmosphere, its beautiful colour fades away. The interior of this is yellow.

Of yellow Copper Ore, I have observed four sorts in general. The first is found shallow among black Ore, small, or not in large rocks; and it can be freely scraped into a yellow dust of a rich appearance. The second is the fine gold coloured flakey Ore, that is rich to the eye and in the crucible; its real value may be from £12 to £15  $\text{per}$  ton: it is this kind of Ore which shoots into distinct and regular tetrahedrons, geometrically defined a triangular pyramid of four equilateral triangles: they are always small, distinct, regular, and of the highest polish; are very common, and as commonly overlooked by the superficial observer. The third is a perfect brass coloured Ore, which rises in great quantities, and is reckoned the best colour of any for its continuance in the Mine: when this comes up in plenty, the Miners please themselves with the sight of it for that reason, although the value may be not more than from £7 to £10  $\text{per}$  ton. This coloured Ore seldom rises before the vein is sunk fifty fathoms deep, or at least not in great heaps; the richer or more inconstant Ores being superincumbent. But the fourth and deepest Copper Ore is of a pale yellow, pretty much corrupted with Mundick, and of an inferior price, being from £4 to £6  $\text{per}$  ton. The superior quantity, however, recompences for its quality and charges of dressing; for it is not uncommon



uncommon for some of those Lodes to produce from 300 to 400 tons of Ore monthly. It is very probable, that the ancients meant this kind of Copper Ore, when they speak of their Native Brass. Our Miners express their sense of the solidity and richness of such a Lode, by saying, "She is as solid as a Brass pan:" and Sir John Pettus, in his *Fleta Miner.* says, "Yellow Copper, for distinction, is properly called Brass in the Stone."

The immature poor Ores of Copper, are constituted of Crystal, (Spar) Earth, Vitriol, Sulphur, Lead, Black Jack, Mundick, &c. and are vulgarly distinguished by the names of Gossany, Sparry, (Crystal) Mundicky, Peachy, Flookany Lodes; according as these appearances may predominate in the Stone or Mineral Ore, of which in their proper places. Some authors call the Ore of Copper, *Cadmia Nativa*; and yellow, or mundicky Copper Ore, they call *Pyrites Aërofus*, and sometimes *Chalcitis*. The green spume of Copper, like Verdigrease, they term *Chrysocola*, or Native Borax; and the blue coloured Spume, they call *Cæruleum Montanum*; and sometimes both by the names of *Ærugo Æris*, or Copper Ochres. (Pliny, Hill, Da Costa.)

Copper is to be found in most countries: of late years, however, Cornwall has produced its portion equal to most of them, to the amount of thirty thousand tons of Ore in the year 1770; and for variety of colours none can exceed us.

By Chymistry we know, that alkaline salts produce a blue colour with Copper, which is changed into green, as soon as any acid is added; and from thence the reason is obvious, why a green colour may be found among calcareous Copper Ores, viz. when the vitriolick acid is in the neighbourhood of it. (Engestrom's notes upon Cronstedt). These menstrua being differently qualified by one another, impart the grey, black, and peacock dyes; but when the menstrua are clear and forcible, they borrow from the Copper, and impart the most piercing tints to precious Stones, making the *Lapis Lazuli*, the Sapphire, Emerald, Amethyst, &c.

Copper Ores are vastly different from Tin Ores; for the former are always visible in the Stone, though much inferior in quantity of Metal to the latter, except some of the grey Copper Ores, which contain as much Metal, as the best of the Tin. By what we have heard of the Ores of other countries, we believe,



believe, that those which we have in Cornwall are much poorer in kind, than any where else : perhaps, in other countries, the poor veins are neglected. This poverty of our Ores, as well as the waste they are so abundantly mixed with, is the source of infinite profit to the laborious inhabitants ; as both sexes of all ages are employed in dressing and cleansing them so as to be fit for sale.

Iron, Ferrum ; Steel, Chalybs ; is called Mars, and has so great a conformity with Copper, as not to be easily separated when soldered together ; whence arises that reciprocal friendship, which the poets feign between Mars and Venus.

It is sometimes, but very rarely, found native, and is the product of most countries. Cornwall has likewise her Lodes of Iron, some of them rich and near the surface, but they are generally small ; and the charcoal for smelting of it is scarce ; at least it is more profitably used for melting of Stream Tin. These reasons, with our vicinity to sundry seaport towns, where all sorts of Iron are imported at first hand, and our natural attachment to Tin and Copper Mining, have occasioned a neglect among us of working our Iron Lodes.

Iron Ore is vulgarly called Ruddle, Reddeng, Oker or Ochre, according to its varieties of colour : the reddest sort of it is thought to be a kind of Red Chalk. Some is stalactical, and called Brush Ore ; and some is fine, soft, and earthy, and called Smit. But those which are mistaken by many for distinct sorts of Fossils, are the Hæmatites, or Bloodstone ; the Magnes, or Loadstone ; the Smiris, or Emery ; and Magnesia, or Manganese, &c. all which are separate species of Iron Ore.

It is the hardest, driest, and most difficult to smelt, of all Metals, and will ignite a long time before it will flow ; yet it is the only Ore that strikes fire with Flint. Malleable Iron is very difficult to be melted, without the addition of Antimony, or some other sulphureous substance ; it will not unite with Quick-silver in any wise ; but is easily corroded and acted upon by every sort of acid menstrua, and by most if not all sorts of Salts. This Metal, in the first smelting, is called Cast Iron, which is brittle ; but is perfected by annealing it in the fire, and then by hammering of it, though gently at first, when it becomes malleable. Steel is made of the best and purest Iron, by cementing it with the hoofs and horns of beasts, and such excrescences,  
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which contain a volatile animal Salt; and being so cemented, they quench it in water, whereby its pores are so greatly constricted, that it immediately grows so hard as to acquire the properties of Steel.

Of all the substances concurring to form the terrestrial globe, Iron seems to have the greatest ubiquity; as it is well known to enter into the composition of Earth, Stone, Plants, and Animals, so truly, that from the ashes of either you may visibly and sensibly perceive its existence, even so as to be discovered in various secretions from human blood, in milk, urine, fat, &c. as may be proved by drawing a Loadstone (whose property it is to attract Iron only) over their calx, ashes, or residuum, when the Iron particles will be drawn out of them, and adhere to the Magnet.

Iron is the most useful to human life: it is our defence and security; and no arts or manufactories could exist without it. Navigation, trade, and commerce, would be at a stand; and even the art of discovering other Mines and Metals, could not be practised without it: so that this, which is considered as the basest of Metals, is indispensably necessary for all the various uses of mankind. Besides the innumerable kinds of instruments made of it, it furnishes excellent remedies in many diseases: by its figure and gravity with the human blood, it becomes a deobstruent and restorative in cold and relaxed temperaments; but in full and sanguine habits, it is inflammatory and dangerous, unless preceded by venesection and other evacuations.

Tin, Stannum; Jupiter. טין in the Chaldee signifies slime, mud, or dirt; and when the Phenicians came into Cornwall, and saw this Metal in its ancient slimy state, they called it, "The Mud:" from thence the name, Tin, (in Cornu-british Stean, in Latin Stannum) has proceeded, and is still continued. Some of the ancients called it Plumbum Album, White Lead, to distinguish it, perhaps, from common Lead. It was by them called White Lead, from its colour and purity; but they did not know it to be, radically, another Metal. We find no Latin name in authors for the Ore of Tin; probably, because the ancients were unacquainted with it as a Metal characteristically distinct from Lead. Neither do the Tanners or Miners call it Tin Ore; for they give it the name of Tin-stuff, as it rises out of the earth; and they distinguish it by several incidents which happen often to it, either from the Ores, or crude Minerals intermixing



intermixing with or corrupting of it; as Pryany, Peachy, Goffany, or Mundicky Tin-stuff: or else according to the degrees of fineness, or smallness, that it is brought to, by stamping of it to a powder. Being pulverized fine, washed, and cleansed, it then has the name of Black Tin; and is, therefore, fit to be smelted into White Tin, or Metal. It does not acquire a real blackness by its pulverization, but is of various colours according to the colour of the stuff with which it is principally mineralized: it most commonly, however, partakes of a brownish or dusky liver colour; and obtains the name of Black Tin, in contradistinction to its metallick colour and properties.

The existence of native Tin remains a doubt among the curious, to this day; but I never heard one reason advanced, why it cannot exist. Although Tin is the lightest of all Metals, its Ore, when rich, is the heaviest of all metallick Ores; inso-much as sometimes to have a greater specifick gravity, than a piece of pure Tin of the same size: this is probably occasioned by the abundant quantity of Mundick with which it is combined.

The Ores of Tin may be generally classed into Shode, Stream, and Bal or Mine Tin. The Shode is disjunct, and scattered to some declined distance from its parent Lode; and is pebbly, or smoothly angular, of various sizes, from half an ounce to some pounds weight. Stream Tin Ore is the same as Shode, but smaller sized, arenaceous, and in its state, is in the form of small pyramids of various planes, very broad at the base, and tapering to a point at the top. In polish and colour, these grains, so called, are glossy jet black, refinous, or red, and are the pseudo garnet, ruby, topaz, &c. The largest single grain of Tin that we remember to have seen, is in the possession of Mr. Giddy, Surgeon, in Penzance, which weighs two ounces, four pennyweights, and twenty-two grains. Stream Tin Ore, is the smaller loose particles of the Mineral, detached from the bryle or backs of fundry Lodes, which are situated on hilly grounds, and carried down from thence by the retiring waters of the diluvium, or floods of subsequent dates, being collected in large bodies or heaps, in the valleys. In the solid rock of the valley, there is no Tin Ore; but immediately upon it, is deposited a layer of Stream Tin of various thickness; perhaps over that, a layer of earth, clay, gravel, &c. and upon that again another stratum of Tin Ore; and so on successively, stratum super stratum, according to their gravity, and the different periods



periods of their coming thither, to the depth of eighteen feet at a medium in St. Austell Moor. In St. Blazey Moor, at the depth of twenty feet, they have what they call Stream (Tin Ore) about five feet in thickness in the bottom, great part of which had been anciently wrought before Iron tools were known, several wooden pick-axes of oak, holm, and box, having been lately found therein. Over this they have a complete stratum of black mud, fit for burning; on this a stratum of gravel, very poor in Tin; on this another stratum of mud; and uppermost gravel again.

Bal or Mine Tin Ore, frequently rises very rich; and instances are plenty, where it has been discovered in the richest and purest state imaginable. Under such circumstances, it has been carried to the smelting-house, as it came out of the earth, and the proprietors have received ten parts in twenty of it in Metal, the smelter having taken to himself perhaps one part more for his expence and profit. Polberou in St. Agnes, which belongs to the Donnithorne family, produced great quantities formerly. In the year 1750 it is said, one rock of Tin from that Mine, weighed 1200 pounds, and produced one half in Metal, clear of all expence to the owner, who gained £100  $\text{per diem}$  for some considerable time.

I observe that this kind of rich Tin Ore, which consists of the blackest grains or Crystals, is usually found at a moderate depth, or within the day side of forty fathoms. Grouan Lodes; so called from their participation of the nature of the adjunct and incumbent strata, do most usually produce those very rich Crystals. But a lofty solid unformed Tin Ore, is commonly the production of all kinds of strata; and, according to my observation, is in itself more independent of any contingent influence. I have seen the same solid lumps of black and dusky liver coloured Tin Ore arise equally alike in form, colour, and appearance, from Lodes in Grouan, Moorstone, Ironstone, Kellas, or Crystal strata. Gossan never exhibits a rich shew of Tin Ore; for it is in that nidus more disseminate and minute. It seldom continues in Gossan, above thirty fathoms from grass. But if we descend from the loftiness of Tin Ore before described, we may find it, although invisible to the inexperienced Miner, very rich and small grained; in which posture it is scarcely known, but by the exceeding gravity of the Stone in which it is enshrined, and the different colour thereof from the adjacent strata. Sometimes it is in blue, gray, black, or brown coloured Lode-stones,



Lode-stones, extremely small ; sometimes veined in the Stones, and branchy throughout the Lode, whereby it may be separated and sorted as it rises, to the saving of much expence in dressing : in other places it may be priany, peachy, flookany, or munday, with which it may be either very prevalent or scanty ; but in the latter, and where Copper participates, it must be well burnt before the true value of it can be known.

This Metal seems to be earthy and very sulphureous ; almost soft and pliable as Lead, but more white and beautiful. Bend a piece of pure Tin, or bite it hard, and it will give a crashing noise or stridor ; but its purity is best known by observing the whiteness or delicacy of its grain, when broke off short. Tin, like Lead, is more easily dissolved in a weak acid menstruum, than in a strong one. It may be easily amalgamated with Quicksilver, and melts almost as readily as Lead ; therefore, it will not bear ignition. It is not naturally very sonorous ; but becomes so, when properly commixt with Copper. It will not easily endure the test by fire ; for as soon as the heat becomes violent it assumes the form of a stubborn ash or calx, which soon loses its fluidity, and is changed into a powder called Putty ; which powder is also made by calcination of Tin, but is reducible into Tin again by melting with a proper flux.

Besides its usefulness in utensils per se, it is also necessary for covering the inside of Copper, Brass, and Iron vessels, to preserve them wholesome for culinary uses ; whence there is a large consumption for tinning Brass ware and the like : it is useful also in foldering ; but I believe the compound Metal of Pewter, of which it is the principal ingredient, is preferable for that purpose. Besides its domestick uses, it is a necessary article, when dissolved in Aqua Fortis, for the new scarlet or Bow die. And if I am rightly informed, our most beautiful and lasting coloured fine cloths owe their superlative excellency to the retentiveness given by our finest grain Tin ; insomuch, that the English superfine broad cloths, dyed in grain by the help of this ingredient, are become famous in all markets of the known world.

It is more than probable, that the purple die of the Tyrians gained the very great reputation it had among the ancients, in great part, if not wholly, from their use of our Tin in the composition of their die stuff, as the Tin trade was solely in their own

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management and direction. I think the known facts of its being their monopoly, the exceeding usefulness of it as one of the non-colouring retentive ingredients, and the fame in all parts of the world of the unfading colour of that purple which is supposed to be given by the juice or saliva of a certain shell fish called *Purpura*, do very much preponderate towards my conjecture.

We may be certain, that almost the sole traffick to this island four and twenty centuries ago, was for this Metal; and we have before observed, that in those very early ages, our Tin was sold to the Phenicians, who (like the present Hollanders, the grand carriers of Europe) transported the commodity in their bottoms to all foreign parts. “Tyrus, O thou that art situate at the entry of the sea, which art a merchant of the people for many isles.” (Ezekiel).

Jesus the son of Sirach, the author of Ecclesiasticus, lived 247 years before Christ. In speaking of Solomon’s glory, chap. xlvii. vers. 18, he says, “By the name of the Lord God, which is called the Lord God of Israel, thou didst gather Gold as Tin, and didst multiply Silver as Lead.” Which shews that Tin in those days, viz. 247 years before Christ, was exceedingly plenty in the Holy Land. And it is remarkable, that Tin and Lead in this place, are both mentioned, and distinguished; so that the latter cannot be taken or meant for the former, as they have been mistaken and confounded together for one Metal by others, though characteristically different. By the ships Solomon sent out, he had a return in one voyage only, of no less than 420 talents of Gold; therefore it is expressed, 1 Kings x. 27. “Money was in Jerusalem as Stones for plenty.” How vastly plentiful must Tin have been then in Jerusalem, to be spoken of in the above figurative way?

We cannot, however, say positively, that no other country produced this Metal in those days; but if it was then known in other nations, it was very little sought after, and was estimated as a staple by no country except Cornwall. Pliny says, it was found in Gallicia and Lusitania, but not at a depth or in quantity to merit much attention. A Tinner, in the time of Richard earl of Cornwall and king of the Romans, upon some disgust at home, went over to Saxony, and taught the natives to seek for Tin, and render it merchantable: they have to  
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this day some workings for Tin, though of no further account, than for their own consumption. Alonzo Barba, says, that they had rich veins of Tin at Oruro and Potosi; but their vicinity to such immense Mines of Silver, is the reason of their being never worked to any purpose. A great deal of Tin has been imported into Europe these latter years from the Moluccas, some bars of which the writer has seen equal to the best Cornish Grain Tin.

Of the Strata of the Earth, and the influence in which Metals are found, their Direction, Inclination, or Undulation.

BEFORE we discover the recesses of our Metals and Minerals, it will be convenient for the reader to have some knowledge and acquaintance with the circumstances, which enclose the objects of our enquiry: pertinent, therefore, to the plan of a late ingenious author, upon our entrance on the subject before us, we will examine the field first, and then consider the kernel.

The Strata of different countries are various; and from enquiry I cannot find that they are influenced by the atmosphere or climate in any degree: and they are not only various, but alterate in their extent, breadth, and depth, in all parts of the world. In the Mining countries, they are found of different densities and gravity, Stratum super Stratum throughout; some hard, some soft, then hard and soft again. Thus we may find, upon a Stratum of Granite, or Moorsone rock; then a softer Granite, called Groun; now Kellas; and so on, to the cornice of the grand abyss. Still a mile distant, the layers of Rock or Stone will be altogether changed in their position or complexion; whereby no absolute rule can be formed, to decide upon the certainty of meeting with this or that Stratum before the industrious Miner has laid them open to view.

I shall not attempt to describe all the Strata that are to be met with; but shall confine myself to Cornwall, and even that part of it which is disposed for Metal, which compose of my B O O K

The general law of attraction evidently appears in the distribution of our Strata; and their specific gravities seem not to determine them so much as might be expected: whence we may



this day some workings for Tin, though of no further account, than for their own consumption. Alonso Barba, says, that they had rich veins of Tin at Otrera and Potosi; but their vicinity to each mine, the richness of Silver, is the reason of their being never worked to any purpose. A great deal of Tin has been imported into Europe these latter years from the Moluccas, some parts of which the writer has been equal to the best Cornish

## B O O K II.

### C H A P. I.

Of the Strata of the Earth, and the Fissures in which Metals are found, their Direction, Inclination, or Underlie.

**B**EFORE we discover the recesses of our Metals and Minerals, it will be convenient for the reader to have some knowledge and acquaintance with the circumjacent Strata, which enclose the objects of our enquiry: pursuant, therefore, to the plan of a late ingenious author, upon our entrance on the subject before us, we will examine the shell first, and then consider the kernel.

The Strata of different countries are various; and from enquiry I cannot find that they are influenced by the atmosphere or climate in any degree: and they are not only various, but alternate in their extent, breadth, and depth, in all parts of the world. In the Mining countries, they are found of different densities and gravity, Stratum super Stratum throughout; some hard, some soft, then hard and soft again. Thus we may find uppermost, a Stratum of Granite, or Moorstone-rock; then a softer Granite, called Grouan; now Kellas; and so on, to the concave of the grand abyfs. Half a mile distant, the layers of Rock or Stone will be altogether changed in their positions or complexions; whereby no absolute rule can be formed, to decide upon the certainty of meeting with this or that Stratum, before the industrious Miner has laid them open to view.

I shall not attempt to describe all the Strata that are to be met with; but shall confine myself to Cornwall, and even that part of it which is disposed for Metal, within compass of my own personal inspection.

The general law of attraction evidently appears in the distribution of our Strata; and their specifick gravities seem not to determine them so much as might be expected: whence we  
may



may argue, that when solids and fluids formed, (and from a state of chaos became divided into distinct bodies) the parts of the former being deserted by the latter, must needs grow closer together. But the masses of Earth, Stone, and Clay, were not at this time merely passive; they formed larger and more compact bodies, every where, according to the mutual attraction of their similar parts within proper distance. It must be further observed, that as all similar parts struggled to come into contact with each other, so at the same time they deserted, repelled, and expressed all dissimilar and contending particles; consequently, masses of different natured particles, seceded and fled from each other, every party (if I may be allowed the expression) tending to unite and combine with its like. Dr. Worthington, in his Scripture Theory of the Earth, says, "All matter gravitates towards all matter; so all homogeneous parts of matter gravitate still more powerfully towards each other, whereby they are more closely united and compacted together, according to their specific textures. Each therefore will assort themselves, and assemble with their kinds respectively." These causes then, viz. the desertion of moisture, the union of similar, and the mutual repulse of dissimilar particles, must all have contributed to form the masses of our terraqueous globe into such separate portions as we now find them in. This accounts for the diverse distribution of our Strata, which by this theory will not be founded upon chance or casualty, as was the case by Mr. Hawksbee's return to the Philosophical Society in the year 1712, when he bored to the depth of thirty Strata of a coal pit.

However, in the natural class and order of our Strata, I shall make my observations in proportion to their hardness and solidity, beginning with the tenderest first.

Soft Grouan, though a Stratum, can scarcely be called a Stone; for it is rather a sandy or priany Stratum of Moorstone gravel, not cemented together, but lax, arenaceous, and mixed with dispersed Stones of Granite. It generally lies at the extremities of the Moorstone Stratum, or hard Grouan. In some places it is so fair or soft, as to run out against the workmen, and requires a great deal of timber to secure it; but notwithstanding this, it encloses numbers of Tin Lodes of considerable value in the parishes of Wendron, Camborn, Crowan, Redruth, Gwenap, Illugan, &c.



Slate is common to many parts of our county ; but, in quality of Slate, is not disposed to secerne Mineral juices, although some thin efflorescencies of Mundick have been seen on the edges of the famous Delabole Slate-stones. The Slate, or Shelfy-stone, is always uppermost next the loamy soil ; but, in depth, it enters into the nature and consistence of real Killas.

Of Killas I have observed six sorts common to us, the white, the red, the yellow, the brown, the cinereous or bluish, and the deep blue. The first is very white and tender, and from its exceeding tenderness is called Fair Ground ; it requires much timber and boards for binding, and securing it from filling the Mine, and endangering the workmen's lives. The red is not so fair, but is well disposed for Copper, or Tin Lodes ; the latter preferably. The yellow is but indifferently disposed for either. The brown, which has various shades of lighter and deeper colours, is generally a hard Stone, and contains Lodes of Tin more commonly than Copper. But of all the Killas, the cinereous or pale blue is most desirable, as the enclosing Stratum of a Copper Lode. We find it the most common and agreeable chest that encloses our cabinets of jewels. Constant experience will incline us to give this Stratum the preference to all others for Copper Mines, on account of its generally accompanying a rich Mine ; and because it is tender and agreeable to work upon in the sinking of shafts and the driving of drifts or adits out of the Lode. It is this kind of Killas which we call Feasible Ground, i. e. to be easily broken, and yet firm enough to stand without the support of binding with timber and boards. However this will oftentimes, by insensible degrees, wear out as we call it, and become a deep blue, hard, unkindly, and costly Killas, neither favourable to the Mine nor the labourer. It will require great address, and much gunpowder sometimes, to break and make way through it. A Killas in its best state, is soft, tender, fleaky, and fatty ; will cut to any form underground, and requires no timber ; but if it is hard and untractable, and works in very small shreds of Stone, it is unfavourable to work or enclose Metal.

Elvan, at a shallow level, is a gritty kind of Stone, most like a coarse Freestone, but in depth is exceeding hard. The two most common colours of this Stone are a bluish grey and a yellow Freestone. It commonly yields great quantities of water ; and we take it to be of the same kind with that Stone which lies on the Culm veins in Wales. It sometimes runs in a direction



tion north, and south, contrary to the metallick veins, which generally keep their course through it, but the Lodes are frequently squeezed up by its accompanying them some length in their course, or are split into many small branches. Sometimes the Fissures or Lodes are thrown short on one side, out of their direct course as it were, by the extreme hardness of this Stratum, and afterwards they recover their course again. At other times the metallick veins are elevated or depressed by it, though they always recover their former direction, and unite again; for this Stratum wears out at a great depth, and is succeeded by Killas.

Moorstone or Granite. The name of Granite, which these Strata have universally obtained, is a modern name given them by the Italian writers, on account of their being concreted into grains, or in a granulous structure, and not compact and uniform as the Marbles, &c. are; thence Granita i. e. è granis composita. The parts of Granite are not homogeneous, but are different concretions of Quartz and Micæ. The varieties are composed of black and white Talc, a dead earth not unlike the white Boles or Pipe Clay, and true Crystal.

We have five sorts common to us, viz. the white, the dove coloured, the yellow, the red or Oriental Granite, and the black or true Cornish N<sup>o</sup> 1 of Hill. Either of these as a Stratum, is called a Hard Grouan Country, (in the Swedish tongue Graberg, and Graften) and the two last are frequently so hard and invincible as to tire the patience and pocket of the adventurers, and the labour of the workmen. Grouan Strata are disposed for Tin, which in such situations is generally of a rich quality, or cannot long be sought after or wrought in its almost impregnable walls. They are seldom likely for Copper Ore; and were long thought to be wholly adverse to that Mineral, till the great Mine of Trefavean proved that rule exceptionable.

The Ire-stone, or Iron-stone, is by much the hardest of all Strata, and borrows this name from its extreme hardness, and not because it contains Iron. It is of a dark bluish colour, like Lead that has been long exposed to the weather; and usually so hard, that it must be wrought with Steel borers, and then blown by gunpowder. It often keeps a course east and west like a Lode, but is commonly very wide; and therefore it is very tedious and chargeable, where an adit must be driven across through it. It is this Stratum that is uppermost through great  
part



part of the middle of Camborn and Illugan parishes, where many principal Copper Mines are enclosed in it. Tin Lodes are very seldom found in Ire-stone, but very rich Copper Lodes in many places are natural to this Stratum or country. We do not observe that it ever gets into the Lodes themselves, although there are some dark hard peachy Stones very like it in some Lodes. The author of a familiar discourse concerning the Mine adventure, says, "It is a constant observation amongst all  
 " Miners, that the harder the rock, the richer the Mine; na-  
 " ture generally makes the case stronger or weaker, according  
 " to the richness of the treasure therein contained: for where-  
 " ever the sides of a vein are cracked and broken, the mineral  
 " water that feeds the vein, runs off, and the vein proves dead  
 " or very poor: but when the sides of a vein are solid and firm  
 " without cracks, the mineral feeder impregnates and enriches  
 " the Mine, and the same proves quick and rich in Ore." This cannot be a general rule, for our theory and observation prove its falsity. It cannot depend upon the confinement of mineral water in one particular place, that a Lode shall be rich in Metal, so much as upon the strength and peculiar attraction of the nidus through which it circulates; for we conceive the attraction to be instantaneous: therefore, water charged with mineral salts or particles continually passing through a vein, will more abundantly impregnate that vein, than if its principles are decomposed, and the water is left pure and unmixed. This is the reasoning of most experienced Miners; for when a rich Lode of Copper, &c. is cut with abundance of water following the discovery, they always declare, "It is a very promising  
 " circumstance."

The foregoing Strata are only common to Tin and Copper Lodes in this county, and if we have not specified more which may be thought of by the discerning Miner, we will nevertheless take upon us to say, any others that may be mentioned will only prove to be varieties of some of these. We cannot learn, that there are either Chalk, Marble, or Limestone, in any part of our mining Strata; consequently real Spar is foreign to our country.

Now when the general assimilation of kindred particles happened, and solid bodies were separated from fluid; between the dissimilar, certain cracks, chinks, and Fissures, in various directions and contortions, were effected at their extreme angles; but as the matter of each Stratum became more compact and  
 dense



dense by the desertion of moisture, each Stratum within itself had its Fissures likewise, which for the most part being influenced by peculiar distinct laws, were either perpendicular, horizontal, or oblique; but at the angles of different Strata, were shattered, ragged, and in all directions. "Linnæus wonders at the nature of that force, which split the rocks into those cracks; but probably the cause is very familiar; they were formed moist, and cracked in drying." (Hill). This may account for the roughness or smoothness of the walls of some Lodes. But whether this theory is disputable or not, we are nevertheless certain, that cracks, or Fissures, are abundant in all parts of subterranean matter; and likewise that those very Fissures are the wombs or receptacles of all Metals, and most Minerals.

The comparative smallness of the largest Fissures to the bulk of the whole earth, is really wonderful. In the finest pottery we can make, by a microscopick view, we may discover numerous cracks and Fissures so small, as to be impenetrable to any fluid, and impervious to the natural optick: therefore if a globe of earth, whose circumference is 24,000 miles, is only split into the very small comparative clefts we behold, how wise and good must that Creator be who hath so contrived by his laws of attraction, repulsion, and gravity, to fix and settle the limits of his creation within their just and proper bounds! No; the great Architect, who contrived the whole, determined the several parts of his scheme, so to operate, as that one useful effect should become the beneficial cause of another. God provided for the uses of things in his first ideal disposition of them; and their respective beneficial uses flowed naturally from each other, thus aptly disposed. Hence it happens, that matter could not contract itself into solid large masses, without leaving Fissures between them; and yet the very Fissures are as necessary and useful as the Strata through which they pass. They are the drains that carry off the redundant moisture from the earth, which, but for them, would be too full of fens and bogs for animals to live or plants to thrive on. In these Fissures, the several ingredients which form Lodes, by the continual passing of waters and the menstrua of Metals, are educed out of the adjacent Strata, collected and conveniently lodged in a narrow channel much to the advantage of those who search for and pursue them; for if Metals and Minerals were more dispersed, and scattered thinly in the body of the Strata, the trouble of finding and getting at Metals (those necessary instruments of art

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and commerce and the ornaments of life) would be endless, and the expence of procuring exceed the value of the acquisition.

“ These Fissures,” says Agricola de Ortu, &c. “ were the “ channels through which the waters retired at the time of the “ creation into the ocean, when the dry land made its first appearance :” and Woodward in his Nat. Hist. thinks they are breaches made in the Strata by the retiring waters of the deluge, prior to which æra (according to his hypothesis) there could be neither Fissure nor Lode. The opinion of the former is easily refuted ; for the walls of the Fissures in some places are too hard to be overcome, and to yield to the power of any current of water ; and in other places too fair and tender to endure the force of such a torrent : besides, their east and west direction, have not that tendency, in our parts, to discharge into the ocean, as they might seem to show, if their courses made for St. George’s channel in the north, and the British channel in the south. With regard to the latter opinion, our Shodes will notoriously evince the mistake ; as the Fissure must be antecedent to the matter of its contents, whose Shodes, it is generally believed, were separated from the superior part of the Lode by the retiring diluvium.

The inside of those Fissures are commonly glidered or coated over with a hard, crystalline, earthy substance or rind, which very often in breaking of hard Ore comes off with it, and is vulgarly called the Caples or Walls of the Lode : but I take it the proper walls of the Lode are the sides of the Fissure itself, and not this coat, which is the natural plaister upon those walls, furnished perhaps by the contents of the Fissures, or from oozings of the environing Strata. We can presently see the breadth of a Lode or of a branch, by the incrufted sides of the Stones of Ore, if brought whole to grass, although we were never under-ground to take the measure of it ; therefore it is common to say, “ I perceive the breadth of this or that Lode, “ to be so many inches wide ; because here are the smooth “ walls or caples affixed to and broke off with the Stones of “ Ore.” But this can be only in small Lodes, and hard Strata, where the Lode breaks stoney. If a Lode is inclinable to yield any sort of Ore, it is the more promising provided the caples or walls of the Lode are regular and smooth, or at least if one of them is so ; but if they are uneven and rugged, it is the less encouraging. There are, however, but few Lodes or Fissures that make regular walls, until they are sunk on a few fathoms.

Thus,



Thus, the medullary or inner part of a Fissure, in which the Ore lies, is all the way environed and bounded by two walls or coats of Stone, which are generally parallel to each other, and include the breadth of the vein or Lode; so that when the Miners dig down or along in a large Lode, then the roof, i. e. the upper, the hanging wall, or incumbent wall of the Lode or Fissure, is (in a certain proportion according to its inclination or underlie) over their heads; and the lower, or other wall or rind, is under their feet: and further, whatever angle of inclination some Fissures make at first in the firm solid Strata, they seldom vary from the same in depth: there are, however, some exceptions to this rule. Some Fissures are very uncertain and different in size; for they may be very small near the surface, or very wide in depth, and vice versa; but as to the regular breadth or largeness of Lodes in their length or direction, they generally make a great variation; for although a Fissure may be many fathoms wide in one particular place, yet, a little further east or west, it may not perhaps be an inch wide.

This variation may happen from several causes, but more especially in very compact Strata, when the Lode or Fissure is squeezed, as it were, through means of hard rocks, which seem to compress and straiten the Fissure. However, a true Lode, Course, or Fissure, is never entirely cut out or destroyed by hard rocks or Strata; for the Fissure always continues through the hardness, yielding a rib or string of metallick Ore, or else of a veiny substance; which often serves for a leader for the Miners to follow, until it sometimes brings them again to a large and rich part of the impregnated Fissure: all which variety of size in the length, breadth, and depth of Fissures, shews that they are the immechanical operations of nature, to fix and settle different congeries of mixed bodies into their peculiar shapes and positions.

As to the length and depth of Fissures, perhaps they seldom admit of any period or limitation; for none can tell how long or how deep they reach: but in regard of their breadth, thickness, width, or largeness, they are limited and various. Though the depth of Fissures is unlimited beyond the power of man to follow after, yet it appears in general, that their fruitfulness for Metal is distinct and limited. The richest state for Copper is between forty and eighty fathoms deep, and for Tin between twenty and sixty; and though a great quantity may be raised of either at fourscore



fourscore or one hundred fathoms, yet the quality is often decayed and dry for Metal.

The Fissures then of Cornwall, which are productive of Metals and Minerals in their progress or direction, are extended east and west; or, more properly speaking, one end or part of the Fissure points and runs west and by south, or else west and by north, or thereabout; and the other end looks or tends east and by south, or east and by north: and thus they often pass through a considerable tract of country, with little or no variation in their directions, except they are obstructed by some intervening cause; of which hereafter, when we come to speak of the interruption of Lodes, &c. Henceforward we shall not always take notice of their deviation from the cardinal points of the compass; but, for the most part, shall consider them as tending east and west, as the only Fissures which are filled with Tin and Copper Ores in Cornwall.

Besides this east and west direction of Fissures, there is yet another of a contrary manner and tendency, which the Miners properly name, the underlying of the Lode, or the Hade. This is the deflection or deviation of the Fissure from its perpendicular line, as it is followed in depth like the slope of the roof of a house, or the descent of the side of a steep hill. Instead of its tending directly downwards to the center of the earth, it inclines either to the north or the south, or nearly so. Suppose, for instance, one side of the roof of a church to be a Lode bared of its incumbent Strata: the length of it east and west, will shew what I mean, by the direction of the Lode or Fissure; and the slope or side will explain its inclination or tendency downward; that is, the north side of the roof underlies north, and the south side underlies south: so that if a Miner should dig down perpendicularly where he first began, or cut the Lode, then it would soon be gone away from him, either to the north or to the south: therefore, when it happens thus, they are often obliged to sink new shafts or pits on the underlie or inclination of the Lode, to cut it in depth, for the ease and conveniency of winding or drawing up the water and Ore in a perpendicular line. This underlying varies much in different Lodes, and sometimes also in the same Lode; for it will often slope or underlie a small portion different ways, as hard Strata on either side may seem to force it. Some Fissures do not alter much from a perpendicular; and some do underlie a fathom in a fathom; that is, for every fathom which they go down in depth, they  
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are also gone a fathom further to the south or to the north, which ever way the inclination or underlie may be. Other Fissures, again, underlie so fast, or obliquely, that they differ not much from an horizontal position, and they are thence called Flat Lodes, or Lode Plots. There is another sort of Flat Lode or Lode Plot, which underlies irregularly with respect to other Lodes or Fissures; for this underlies or widens horizontally for a little way, and then goes down perpendicularly not unlike stairs, with only a small string or leader to follow after; and thus they alternately vary, and yield Ore in several flat or horizontal Fissures. Yet this kind of Fissure is very rarely met with, and is wrongly called by the Tanners, a Floor or a Squat, which properly speaking is a hole or chasm impregnated with Metal, that makes no continued line of direction, or regular walls; nor yet goes down any considerable depth; for when a Floor of Ore of this sort is dug away, there appears no footstep or sign of a vein or Fissure, either under foot, or pointing or leading any where else. Alonzo Barba, in the Spanish tongue, calls it a Sombrero, which signifies a Hat or a Heaped Mine, where Metal is found in a heap together. In Cornwall, they call it a Bunny of Ore or Tin; and sometimes "The Pride of the Country;" which last epithet we apprehend more properly belongs to the Bryle or loose shattery back of a Lode, when it is very rich for Tin or Copper, immediately to the day or surface. Instances of Bunnys of Ore are very rare with us. We have heard of such among the Tin Mines in St. Just, near the Land's End; and that there are several such chasms, impregnated with Copper or Lead, in Wales and the north of England, where they are called Pipes of Ore. In the latter we have been informed of a Pipe of Copper Ore, called Eaton Mine, which is two hundred fathoms deep, the Sough or Adit being one hundred fathoms below the surface. When those Pipes are exhausted, if they find water come in upon them, they work to meet it, without regarding what point of the compass it flows from; and this oftentimes leads them to another Pipe or Bunny of Ore. Likewise, if a few Stones of Tin are found dispersed in our soft Grouan Stratum, by properly remarking the tendency of these Stones, and where the heaviest part of them points, it may be nearly guessed how far off another little Pipe or Bunny of Ore may be; or, at least, they will bring you to what is more natural, a true Lode, as we every day experience in our discoveries of Tin Lodes by Shodeing, as will be hereafter described.



After all; the Fissures which are common to us, are the perpendicular, and the inclined, let their direction be either north and south, or east and west. Be they impregnated with Metal, or quite barren and void of Ore, they are usually such as we have above described; and when any Floor, Pipe, or Bunny of Ore is met with, we look upon it as a very uncommon disposition of Metals in Cornwall.

Perpendicular and horizontal Fissures, probably remain little altered from their first position, when they were originally formed at the induration of Strata immediately after the waters deserted the land. Respecting the former, we find them more commonly situate in level ground, and at a distance from hills, or the sea shore, where the Strata might make less resistance to secondary accidents. But with regard to the latter, we find that the upper and under masses of Strata, are different in their solidity, and other properties; whence their formation, pursuant to their distinct and natural efforts to join each with its like, and to separate from those which are unlike. Hence it is very apparent to us, that inclined Fissures owe their deflection or underlie, to some secondary cause, violence, or subsidence of the earth: for though perpendicular Fissures are seldom seen, yet the inclined at a very considerable depth become more downright, the central Strata being not so liable to be wrested from their primary position, as those more near to the surface, on the sides of hills, and the cliffs of the sea shore, of vallies, and of rivers. It is more than probable, that fundry and diverse agitations and subsidencies have been effected since the creation, nay even in our own time and knowledge; which could not but influence, in various degrees, all the adjoining Strata, and their Fissures or Lodes.

Fissures are not only inclined but fractured; which fracture must have been the effect of violence. The inclination also must have been the effect of force, though, in many instances, that force only bent, and did not proceed to that degree of violence, as to break it short off, but only to occasion what we call the underlie of the Lode. Now if we can discover the probable cause of the inclination or underlie of Fissures, the same cause, allowing it but a greater impetus, will account for that fracture which we call a slide or a heave.

Betwixt the underlie of Fissures, and the dippings of the adjoining Strata, there is oftentimes so manifest an agreement  
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and correspondence, that whatever occasioned the latter could not but produce the former. Let us first note the dippings of the Strata; for if they have also been wrested, their Fissures, or the Lodes contained in them, could not have preserved their station. The original position of Strata must have been horizontal or parallel to the surface of the earth; but we often find those Strata very sensibly declined from that first position; nay sometimes quite reversed and changed into perpendicular. When we see a wall lean, we immediately conclude that the foundation has given way, according to the angles which the wall makes with the horizon; and when we find the like declination in Strata, I should think we may conclude, by parity of reason, that there has been a like failure of what supported them, in proportion to that declination; or that whatever made the Strata to fall so much awry, must also cause every thing included in those Strata to fall proportionably. Wherever the greatest subsidence is to the north, the top of the Lode or Fissure will point to the north, and in consequence underlie to the south; and vice versa; the slide or heave of the Lode manifests the greater subsidence of the Strata, but the same Lode is frequently fractured and heaved in several places: all of which, by due observation, will shew us, they were occasioned by so many several successive shocks or subsidencies; and that the Strata were not unfooted, shaken, or brought to fall once only, or twice, but several times. (For uncommon subsidencies of the earth, see Philos. Transact. 337. 349. and 405.)

The cause of the underlie, interruption, or fracture of our Lodes or Fissures, being given, it remains to account in some measure for the cause of those subsidencies, which is the efficient Aristotelian "id unde," from which the others originate.

When the Almighty Architect, in his infinite wisdom, foresaw the necessity and usefulness of mountains and vallies, he suffered the more lax and weaker Strata to sink into the abyfs, either totally as in the depths of the ocean, or partially as in coombs, dales, and vallies; and the more compact and stony Strata were left to form the mountains and hilly parts of the land. It must necessarily follow that when those subsidencies happened, the adjunct Strata must have been proportionably affected, and likewise their Fissures; hence so manifest a relation in the Strata and their Lodes in many places, to these first and principal depressions.

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The encroachments of the sea from time to time, by its fluctuating pervading ebb and flow, hath searched out, and carried off many of the laxer substances between the Strata; nay it hath even, by its own force and violence, destroyed large portions of solid rocks and cliffs, which is well known by every person acquainted with the sea shore: these, together with the larger submarine gulphs or swallets, cannot but influence the maritime Strata, and produce secondary subsidencies of the earth; to which we may ascribe those contrary and irregular underlies of Fissures with us, who are so narrowly situated between the two channels, and whose Lodes are remarkably distorted thereby in the parish of St. Agnes, and elsewhere on the sea coasts.

One more effective cause of the dislocation of Lodes, is that of the general deluge; which deluge, in the parish before mentioned, is evidenced not only in the multiform fractures and interruptions of the Lodes, but in the distinct and solitary mountain, called St. Agnes Beacon, in the proper British dialect, Carne Bury-anacht, or Bury-anack, the Still Spar-stone Grave; where, suitable to the name, on the natural remote eminencies thereof are raised three Quartz-stone Tumuli. The natural circumstances of this mountain are worthy the consideration of a philosopher: for though it is a very high mountain, abutting on the Irish sea or St. George's channel, and rising pyramidally from the same at least five hundred and forty feet above the sea, yet on the top thereof, under those Tumuli, is discovered by the Tinnars five feet deep good arable land or earth; under that, for six feet deep more, is a fine sort of white and yellow clay, of which tobacco pipes have been made; and beneath this clay is a Stratum, or layer of sea sand, and smooth beach pebbles. Two or three hundred fathoms from the sea, and about eighty fathoms above it, under this sand, is to be seen for five feet deep nothing but such beach Stones, as are usually washed on the sea shore, and in many of them grains of Tin: under those Stones, the soil or matter of the earth for six feet deep; and under that appears again the firm rock, through which Tin Lodes have been wrought at fifty, sixty, or seventy fathoms deep.

It would be needless and impertinent to enter here upon a disquisition into the universality of the deluge, and the natural means the Almighty used to produce so unparalleled an event: the greatest naturalists and philosophers have given different  
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and contradictory solutions of it. I beg leave, however, to observe, that we are supplied with innumerable evidences of this grand phenomenon; and notwithstanding we have no exuvia of land or sea animals buried in our Strata, yet this mountain, of which we have just spoken and given the particular circumstances of its site and contents, is at once a production and an irrefragable proof of Noah's flood.

It is agreed by most naturalists, that some parts of the present dry land were, before the flood, part of the ocean's bed; among which, I suppose, the top of this mountain was placed, till the Almighty cause moved upon the surface of the waters, and directed the bottom of the sea to inflate and elevate the mountains of the deep, and thereby diffuse its waters, and level the surface of this earth. But when the vengeance of Omnipotence was finished, he commanded the sea and the waters to retire into their former reservoir; whereby the land appeared again, though not uniformly the same as it was before; neither was it necessary it should be so, so long as it was sufficient for all the purposes of life. At the same time, the Father of Mercies left those remains of his power and justice, to convince us by nature, as well as revelation, that he is able to do all things.

If we may have credit for this hypothesis, we are to believe also, that some parts of the elevated deep returned to their first stations, and that others remained and became the present dry land, which was before the bottom of the sea; whereby we presume to account for the appearances under the surface of St. Agnes beacon, and those distortions of the Strata, &c. in our parts, some inclining one way, some another, and some quite reversed. Neither will this elevation of the deep, and concomitant subsidence of the land, appear unnatural to our idea of the matter, when we consider that the loftiest mountain upon the face of the earth, is not quite four miles in perpendicular height, which in fact amounts not to one six thousandth part of its circumference; and bears not so great a proportion to the bulk of the earth itself, as the little risings on the coat of an orange bear to the bigness of that fruit.

There can be no doubt, that many alterations have happened to various parts of the earth, before, at, and after the flood, from inundations, earthquakes, and the dissolvent powers of subterranean fire, and water; which variety of causes and circumstances must infallibly have produced many irregularities



in the disposition and situation of circumjacent Strata and Lodes.

Having, as succinctly and clearly as I am able, delivered my own and other people's opinion upon these matters, I shall, in the next place, proceed to examine the contents of those Fissures and their properties; wherein a local and peculiar natural history will be so evident, that I shall hold myself excusable to systematick naturalists, if I appear to them irregular and immethodical in the manner which I shall take to pursue my subject. As I have also shewn the cause, nature, and variations of the Fissure, I shall in future make little use of that term; but in compliance with the custom of my country, shall indiscriminately call a Fissure, or its contents, the Lode: for instance, when I come particularly to define and describe the interruption and disorders of Lodes, I shall say that this or that Lode is heaved to the right, or to the left, up or down, by a cross Lode, a Contra, a Gossan, a Slide, a Flookan, or the like, pursuant to the idiom of our Miners; without taking notice of the Strata, upon which such alterations of Fissures and their veiny substances depend.

We have ventured to advance the foregoing hypothesis, as the most likely to account for those appearances which occur in the bowels of the earth; and we are not singular in it, but are supported by the concurrent opinion of some very approved writers upon part of the same subject. And though we are sensible that some objections may be started against it; yet we can scarcely think, that those who may be most forward to deny it, are supplied with one that will more rationally point out the causes of these appearances we speak of. As, however, we do not insist upon the infallibility of our sentiments, we shall submit them to the naturalist and philosopher with the greatest deference; and shall be extremely glad to find, in our own day, the errors of our theory rectified by some abler pen.



## C H A P. II.

Of the different kinds of Lodes in respect of the Earth and Stones they contain.

**T**H E contents of our Fissures are very complicated, and obtain their several distinct appellations from the nature and appearance of the most predominant Earth, Clay, Stone, or Mineral, contained in them; without any respect to the metallick impregnations of Tin, Copper, or Lead, unless the Ores of those Metals are very rich, and more abundant, than all the other contents of their Fissures. The same Lode, at higher or inferior levels, shall be alternately named a Goffan, Mundick, or Flookany Lode, pursuant to their predominancy at twenty, forty, or sixty fathoms depth; or any other intermediate level they may offer to the observation of the Miners. Upon this account, most Lodes take their names from the kind of Stone or Mineral they most abound with, which often participates very largely of the nature of the Strata enclosing them.

The generality of our Lodes are very different to the eye and in their impregnation, near the surface, from what we find them when deeply sunk upon; and though it has been known, that the backs of some few veins have proved very rich, yet they do not always hold Metal, and frequently they do not carry Tin or Copper Ore enough to pay the charge of dressing or cleansing them: nevertheless, in the sinking upon such veins, we hope they will depart from their primary colour and appearance, and form large bodies of Tin or Copper Ore.

The slight metallick impregnations of our Lodes, which, especially in Copper, are generally observed to fifteen, and even thirty fathoms deep, must certainly arise from the scarcity of saline mineralick principles, which the water so near the surface cannot be largely saturated with; and having less depth of Strata to receive the metallick solutions from, they of necessity cannot be furnished with strong menstrua, to act upon the Lodes, or deposite themselves. Although Mines are seldom discovered rich upon the backs, we presume for the reasons before given; yet experience will inform us, that they are sometimes well stored with Copper and Tin Ores of the richest quality near the  
day



day or surface ; but this more frequent in the latter, though of no long continuance.

We shall divide Lodes which carry Tin, Copper, and Lead, into twelve different kinds, in regard to their foreign Materials ; and the removes visible in them, we shall class into their proper subdivisions. The Lodes are ranged in the following order :

- |                     |                       |
|---------------------|-----------------------|
| I. A Goffan Lode.   | VII. A Crystal Lode.  |
| II. A Peach Lode.   | VIII. A Killas Lode.  |
| III. A Scovan Lode. | IX. A Mundick Lode.   |
| IV. A Caple Lode.   | X. A Black-Jack Lode. |
| V. A Pryan Lode.    | XI. A Flookan Lode.   |
| VI. A Quartz Lode.  | XII. A Grouan Lode.   |

I. Of all these Lodes, the Goffan is most common ; and is ever disposed to yield Tin and Copper, if it runs east and west ; but those of a contrary direction, in respect of those Metals, are sterile and worthless. Goffan may not improperly be divided into five sorts : viz. 1. a Tender Red Goffan ; 2. a Tender Brown Goffan ; 3. a Dry Pale Yellow Goffan ; 4. a Poor Tin Goffan ; and 5. a Gal or Gally Goffan : all of which are ochreish substances, of a rusty ferruginous complexion, being mostly Earth and Crystal coloured by Iron, with frequently no inconsiderable portion of that Metal.

1. The Tender Red Goffan is very much inclined to produce Copper Ore, especially if the Goffan be spongy, cellular, and of a very red colour, like to a well burnt brick. When it is thus, and spotted, or tinged with green Copper Ore, like pieces of Verdigrase, it does not often deceive the proprietors. So, likewise, Stones of blue or black Copper Ore, or of yellow Ore having a black or purple outside, are very hopeful to follow when mixed in this Goffan. Yet the Ore in this nidus is bunchy and uncertain, till proved to some tolerable depth. But if Stones of Lead Ore be found in this Goffan, it promises well to produce a good quantity of Lead. This kind of Goffan was upon the back of Pednandrea Lode, and some parts of Huel Sparnon, and is now very plentifully to be risen at Michell's Goffan Mine, in Redruth.

2. A tender Brown Goffan, much of the colour of Iron, very brittle, and full of holes. The smaller particles of it are of a brownish yellow, very crumbling, and fall to dust by long exposure



exposure to the air. It is this Goffan which backs the Huel Virgins in Gwenap.

3. A Pale Yellow Dry Goffan, of a hard crystalline intermixture. This sort of Goffan sometimes yields Copper Ore, yet seldom turns to any great account. However, I believe it to be more promising for Lead than Tin or Copper, as I have observed it to produce that Metal in Nanskuke Downs and elsewhere. This must be most like the Goffan of Hernn Groundt Copper Mine in Hungary, the mother of which Ore is yellow, says Dr. Brown, Philos. Transf. 59.

4. A Poor Tin Goffan, implies that which is so in respect of its yielding Tin; for otherwise, it may be kindly enough for Copper. This Goffan sometimes will yield a very tolerable profit, on account of its cheap and speedy working for Tin. If it is red and brittle, it is a good indication of Copper Ore in depth, as the Tin lessens and wears out; and if it is tinged with Verdigrease, it is very hopeful indeed. Formerly, a notion prevailed, that every Goffan which did not produce Tin upon the backs, was not worth the attention of the concerned for Copper; but it was a vulgar error derived from father to son, in times when Copper was very little known. Huel Virgin, and other great Copper Mines, have proved, that Goffans not productive of Tin, will yield abundance of Copper.

5. A Gal, (Kal) or Gally Goffan, is of a hard compact nature; its colour blacker than the other Goffans, and more like rusty black Iron. This makes Tin; but it very seldom answers for Copper, unless it changes to tender and brittle. This Goffan contains so much Iron, that it sometimes ought to be ranked as an Ore of that Metal: I have been informed by my friend Mr. Bennallack, that he has assayed some Stones of this Gal, which have produced three-fifths of their weight, good Iron; but this is seldom found in considerable quantities, and its different Lodes are impregnated therewith, from this large to an exceeding small proportion.

Though all these Goffans have an intermixture of each sort, yet that which is most abundant, gives the Lode its denomination. A tincture like Verdigrease is not to be rejected in any of them, for it is very promising for Copper.



II. A Peach or Peachy Lode, takes its name from a kind of Stone which principally abounds in the Lode, and is generally of a spongy texture, and of a greenish or dark green olive colour. It is better for Tin than Copper; but is not a desirable Lode for either, especially the latter, which is always of a poor quality and value when found in a Peachy Lode.

III. A Scovan Lode, is formed of a hard compact crystalline Stone, either of a brown or black hue, according to the colour of the Tin with which it is mixed. The Ore is often rich, ponderous, and solid in this Stone; and when it is worth one half for Metal, they call it Scove. The Lode is usually very small, from the breadth of four inches to fourteen; the latter is thought to be a tolerable size; and, notwithstanding its solidity and demand for gunpowder to blast it, will yield much profit to the adventurers under other favourable circumstances. Sometimes this Scovan Tin lies in a less solid Lode, as to the Lode itself, which is cavernous, and full of holes, thence called a Sucked Stone by the Tanners, as if all the heterogeneous matter had been sucked or rather washed out of the Stone, and nothing was left behind but pure solid Tin Ore. This sucked Scovan Lode is larger when it occurs, even to some feet in breadth; and so is the solid Lode likewise at times.

IV. A Caple Lode. The Scovan Lode, when in decay for Tin, will commonly degenerate into a Caple; which, in fact, is mostly of the nature of a Scovan Lode's walls, or that enclosing Stratum, which it is in contact with; thence called the Caples, or walls of the Lode. But there is really such a thing as an original Caple Lode, properly so called; which abounds with a very stiff hard Stone, something like a Limestone, except the colour; wherein the Tin is sometimes veined, and other times very small and disseminate. A primary Caple Lode is promising for Tin, though but seldom so for Copper; unless there is a branch of Copper Ore or Gossan, that runs downwards in the Lode: if this Caple chances to hit into a body of Copper Ore, it commonly makes a durable Mine though the Ore is none of the richest.

V. A Pryan Lode, is so named, not in respect of any peculiar quality of the Earth or Stone, any further than barely that it lies in the vein, in an arenaceous pebbly state, with small Stones of Ore intermixed, and not in large rocks or Stones; in which sense, a Gossan, Flookan, Mundick, or any other Lode,  
may



may be called a Pryan Lode. This sort of Lode is very tender, and apt to yield Tin of the purest metallick quality. The Lode is often so very lax and sandy, that it will run against the workmen like a sand bank; and the man who handles his shovel best, is preferable to a Pick-man. If the walls of the Lode are tender likewise, it requires much timber to bind and keep open the workings. When Copper Ore is Pryany, it comes to grafs very cheap and speedily, and produces a quick profit.

VI. A Quartz Lode, or Rampant Spar Lode, vulgarly so called, is placed by some among the Gossans, though I do not see for what reason; this being a hard unmetallick petrification, thence called a Spar Lode by those unacquainted with real Spar. There is no Lode totally exempt from this Stone; and many branchy veins of it are to be seen throughout all our strata, unmixed with any other matter. In the gros here spoken of, it is a hard, opaque, yellow, or white crystalline exudation, from the adjoining Crystal rock.

VII. A Crystal Lode. Quartz is undoubtedly the most debased kind of Crystal; yet with regard to Crystal Lodes, I can from experimental knowledge make four other distinctions, whereby their good or evil tendency for Tin or Copper, will more evidently appear.

1. The first is a greyish white, dull, hard, opaque, and rocky Crystal, which produces no Metal in itself, or in those Lodes which degenerate into its kind; for even if there are some Stones of Ore found in other Lodes, yet where this comes in, it is a certain prognostick of sterility and decay. It is most natural to Tin Lodes at a great depth.

2. A smutty black, or black grey Crystal, is a very unlikely appearance for Copper Ore. It occurs but seldom; and when it does, it betokens a very sudden decay, though the Lode was fruitful before.

3. A brown candied, or amber coloured Crystal. This is small, tender, and very like brown sugar candy. I take it to be hopeful for Copper; and it mostly abounds with a black Pryany Copper Ore, which last consistence it imparts from its arenaceous property. This wears out in sinking, and the Lode generally changes to a yellow Ore, and solid Stone.



4. A white candied, or pellucid Cryſtal, commonly termed a White Sugar Candy (Spar) Cryſtal. This, if it is mixed with Goſſan and Stones of Copper Ore, is very likely to abound with great quantities of Ore, but the Cryſtal muſt be very tender, lax, and ſandy. Alſo if it is clear, or tinged with green or purple, it is very promiſing for Copper; and diſappoints the patience and purſuit of the adventurers, as ſeldom as any Lode.

All theſe Cryſtal intermixtures, are very often found in different parts of the ſame Lode; and the nature and qualities of the Lode vary accordingly. The two latter are moſtly in Copper Lodes, and ſeem to be more particularly the Cryſtal Septa of Goſſan Stones in a broken ſhattered ſtate, by the diſcharge of its Mineral Earth or Ochre.

VIII. A Killas Lode. All Lodes, except this, derive their names from the coat they wear upon their backs; at leaſt their firſt names are given in conſequence of their firſt diſcovery: but in this before us, the caſe is otherwiſe; whence ſome may object to the name of this Lode adopted by the writer; but they may as well demur to the received name of a Grouan Lode, or any other which participates of the environing ſtratum. Goſſan and Scovan Lodes, which are rich upon the backs, in depth come (though very rarely) into the nature and qualities of the enclosing ſtratum of Killas. The red Killas bears Tin; but it is dry, barren, and ferruginous: the brown is common with Tin, and is hard and Capley: blue Killas, in depth, is ſometimes blended with Copper Ore by the cementing medium of white Cryſtal. If the Killas is tender, fat, and fleaky, it is ſpeedily wrought, and agrees well with its united Ore; but if it becomes exceeding hard and ſtubborn, the Ore is impoverished and chargeable to break. I ſpeak of this Lode as a Rara Avis, and merely adventitious.

IX. A Mundick Lode. Some Lodes are moſtly compoſed of rank Mundick near the ſurface, and too often continue ſo in depth; but there are inſtances, of their being richly blended with Tin and Copper in further ſinking. “ The Pyrites (Mun-  
“ dick) proves a ſure guide to Lead and Copper Ores, which  
“ with us are not eaſily ſeparable; ſeeing they generally lie ſo  
“ mixed together, or ſo near each other, in one and the ſame  
“ view, that it appears almoſt impoſſible for the one to be  
“ without the other: and, indeed, it is no eaſy matter to  
“ find a vein in the earth, in what direction, and to what  
“ depth



“ depth so ever it runs, unaccompanied with Pyrites (Mundick).” (Henckell).

In case the Mundick associates with a rotten, black, ferruginous earth, which contains Stones of Copper Ore, it bids fair for an agreeable alteration. By sinking in a bed of Mundick, or driving through it on the course of a Lode, it may probably alter and come into Copper Ore. On the contrary, if a Mundick Lode continue hard and inflexible, it portends no good. Tin or Copper Lodes, that change their metallick impregnations for Mundick, and hardness, are better deserted than followed.

X. A Black-jack or Mock-lead Lode. This is very shallow and rich both in its nature and appearance. It is composed of flakey, tabulated, polished, shining, fatty, black earthy Stones; and, like many other Minerals, is most rich, in proportion as it is less hard. This is one of the Zinc Ores, and it has been used in some quantites instead of Calaminaris; but it is so corrupted by a certain admixture of Iron, that it holds an inconsiderable estimation among the workers in Brasses. This Wild-lead is commonly found with Stones of Copper and Lead intermixed with it; but it seldom or never has any Tin. If it assumes a hard nature in depth, and breaks off in great jointed rocks, it is a bad sign for Copper Ore; and that which is got in this sort of Lode, is never very rich in quality. We have been assured by some who are conversant with assaying Copper Ore, that where the Ore has been much corrupted with this Black-jack, their assays had the appearance of and undoubtedly were a very coarse Brasses.

XI. The Flookan Lode takes its name from that tenacious glutinous Earth or Clay, that sometimes runs without side some veins, immediately between either wall of the Lode and the Lode itself, and more frequently I believe adherent to the hanging or superior wall. At other times it is intimately mixed in and throughout the Lode itself; and if the vein exceeds eighteen inches in breadth, it is very troublesome to keep from running against the workmen, and takes much timber to secure the backs, ends, or other parts of the Mine, which they chuse to leave unwrought. It is generally of a bluish or whitish colour, or else shaded between both of a clouded cerulean cast. If Stones or Pebbles of Ore be found in a vein of Flookan, it is  
B b very



very likely to make either Tin or Copper Ore in depth; and the latter in most abundance, if there is a Goffan branch or leader.

This Flookan or clay-matter in its barren unmetallick state, is seldom absent from a cross course or cross Goffan, either adjoining to one wall of the course, or like a pith in the center thereof; and is the preventive whereby the water from the east or west of it cannot circulate from the true Lode through the cross Goffan. Flookany Goffan Lodes running east and west parallel to Scovan or Tin Lodes, if they meet in opposition to each other upon the hade or underlie, will sever at the angle of incidence, and will heave such Tin Lodes higher up; by which means sometimes a deep work has become as it were renovated, so as to make a new back and new work. But of this in its proper place.

XII. The Grouan Lode abounds with a kind of rocky Stone of that name, either casually very soft and tender, or very hard and invincible to pick and gad, unless first blasted by gunpowder: where Lodes do abound with this Stone, it is always in a stratum of its own kind, usually called a Grouan or Moorstone-country. It is an aggregation of coarse, angular, arenaceous Pebbles, or fragments of Quartz and Cockle, cemented together by a crystalline juice, and variegated with small scales of black or silver shining Talck. When Tin Ore happens in these Lodes, it is always good in quality; but they seldom miss of deceiving those who seek for Copper or Lead: and when a Goffan Lode happens in a Grouan stratum or country, it is not so inducing to adventure in, as when it happens in a Killas country; but that it is totally unpromising for Copper Ore, the Mine of Trefavean will contradict.

We again remark, that what we have said above on the different sorts of Lodes, is mostly on a supposition of their being discovered shallow; and also, that they frequently change and vary, both in depth and also on the course of the Lode; so that in order to make a satisfactory trial of a vein, the Miners must "spend ground," in other words, they must sink down, and also drive on the course of the Lode, before they can form a right judgment, whether it may prove successful or not: and though a prudent caution forbids every thinking person to engage improvidently and deeply in a Mine which has discouraging symptoms; yet, on the other hand, it is often seen, that on  
trying



trying of Lodes, they alter in their nature and properties very much: however, while a Mine carries a bad appearance, it merits but little regard and attention. All the dry hard Gossans, the Peach, the Pryan, the Caple, the Scovan, the Mundick, and the Grouan Lodes, are liable to yield Tin; and the tender Gossan, the tender Cryстал, Killas, Mundick, Mock-lead, and Flookan Lodes, are disposed for Lead or Copper Ore; especially if they produce Stones of their own proper quality and nature, or are tinged with Vitriol. Experience shews, that the hardness of a vein or Lode near the surface, always denotes no good disposition for Copper or Lead; nor is it always a good sign, to meet with Copper Ore at a shallow depth: but as to Tin the case is opposite; for it is often found rich in a hard Lode, and at a small depth, the richest Tin Lodes we have being in a very hard Stone; yet a tender Lode often produces Tin as well as Copper; and, upon the whole, I would prefer a tender Lode for both.

Stones of Ores or Metals, have their sinuses or joints, the same as common quarry Stones; and those sinuses often facilitate the breaking and working of the Ore, because the labourers are thereby at greater liberty to drive their gads or iron wedges into such joints or divisions, in order to break the solid rocks of Ore. When a Lode breaks away in large jointed rocks, be it of what kind soever, it implies no good for Copper or Lead; however, if it chances to alter and prove better for either, it generally makes a lasting Mine: sometimes it so falls out, that as a tender Lode comes into Ore in depth, it proves so hard, that they are often obliged to bore holes in it, and blow it with gunpowder; and yet the Mine shall be very rich, lasting, and profitable.

We must not omit some particular sorts of Stones, which are often met with in Lodes, though the veins are not called by their names; because the Stones do not continue, except for a short length, and small depth. There are also some other Stones which are very troublesome to the labourers, and very chargeable to the adventurers.

Among these the Elvan Stone is very common; which is a sandy gritty Stone, mostly very hard, and of a pale yellow, or whitish grey colour. When it is found in a Lode, it forebodes no good success in that part where it lies; for, as far as it continues, it is said to starve the Lode with respect to Copper  
or



or Lead, although sometimes it does not prove very hurtful to Tin. Another sort of Stone is often met with in Lodes, which they call a Liver Stone, or Livery Stone, from its usual liver colour. This is generally very hard, and apt to impoverish the Lode; but when the Miners work a little further or deeper, they commonly come to an alteration of ground, and then the bad effect of these Stones alters likewise.

It frequently happens in very large and also rich Lodes, that when they dig a great depth in them, there appears a kind of Stone about the middle of the vein, of the same nature of the ground or stratum nigh the Lode, being not at all of a veiny quality, though it is in the body of the Lode. This is mostly of the Killas kind, it being the common stratum at a great depth. It will first be discovered, perhaps, in the middle of a vein; and will spread as you sink upon it, like the back of a horse pack saddle, till it occupies the whole breadth of the Fissure, except one or two strings or leaders of Ore on both or either side of it. The Cornish Miners call it a Horse; and when they meet with it say, "The Lode has taken horse." The continuance of this unwelcome stranger, may be for the sinking or driving of several fathoms of ground; and it may be thought expedient sometimes to sink and drive under it, through it, or at one end of it, and leave the greatest part standing, which may save expence, and be useful to keep open the workings, if its footing or support at the bottom is not unskilfully wrought away by the incautious Miners. Thus, by sinking and driving, according as place and circumstance will admit, they recover the Lode again: however, it is always suspected whether the Lode will continue so rich and plentiful as before; and it has so happened, that the Lode has never recovered its former good quality.

At, or soon after the time, when the split, crack, or Fissure, in such place happened, a part or side of the Fissure being more lax and incompact, separated, fell off, and lodged upon the lower wall of the Fissure: which seems to me, the only accountable cause for the formation of those large Horses we sometimes see in Lodes; and in support of my opinion, I remark, that the contents or substance of a Horse, is less hard than the Stratum from which it was separated, it being of a shattery loose texture, like a flatty Killas. It generally occurs where the Fissure is largest; and the continuity of the veiny part of the Lode each side, further corroborates the idea.

Therefore



Therefore it is no wonder, when injudicious Miners work away the footstool of a Horfe, that they should pay for their temerity, by the forfeit of their lives; yet such has been the case, and the adventurers have been often put to unnecessary expence in stemples and lock-pieces to secure the Mine from falling in.

It is observable in driving, or stoeping upon the course of a Lode, that when it changes from its usual underlie to nearly perpendicular, and then the lower wall starts off from its common underlie, to that which is contrary, and the Lode or Fissure widens pretty much; in such case the Miners expect to meet with what they call a Horfe: but unless they come down in sinking upon the back or top of it, they seldom call it by that name; and when met with in stoeping, or driving as aforesaid, they commonly say, "It is a stoep of dead ground."

### C H A P. III.

How Mines are disordered, interrupted, fractured, elevated, and depressed, by the Intervention of Cross-Gossans, Flookans, Slides, Contras, &c.

**L**ODES are not interrupted, fractured, heaved, or otherwise disordered, by the intervention of Flookans, Cross-Gossans, Slides, or the like: it has ever been the mistake in this case, to substitute the effect for the cause. I have already shewn, that the fracture and heave of a Lode, is produced by a subsidence of the strata, from their primary positions; so that what we call a heave, is a false term, and altogether contrary to the idea I conceive of the matter; for, instead thereof, it is a sinking of the strata, and ipso facto occasions a depression, subsidence, or sinking of a Lode, instead of an elevation or heave. Nevertheless, in compliance with the phraseology of our Miners, I am obliged to use that dialect which is commonly known and received among us. It will be difficult, nay almost impossible, to persuade thirty thousand illiterate persons, that their notions are wrong, and their expressions inaccurate. I must, therefore, proceed in the usual style of the Tanners, and write as they converse upon those subjects.

C c

We



We have already observed, that our veins generally run east and west; but this must be understood of the metallick veins; for there are some, which run quite across them, that is, north and south, or obliquely so, with some small deviations from those cardinal points: these are called Cross-Lodes, Cross-Courses, Cross-Flookans, Cross-Gossans, and Contras or Caunters. They are generally quite barren for Tin or Copper; but we have some few instances of Cross-Gossans being wrought for Lead, though not to any great profit. Some antimonial veins run also north and south.

The Cross-Gossan runs straight on, without any interruption from other Lodes; for it seems to be irresistible in its stretch through the earth, breaking through and intersecting all metallick veins it meets with, separating and throwing aside the correspondent ends of those veins from each other, perhaps twelve inches or twenty fathoms. The underlie of those Cross-Gossans are either east or west, little or much, like other veins. These Cross-Lodes are not without their use; for in bringing home adits, they afford an easier passage, than perhaps the solid strata would have permitted, especially if a stratum of Ire-stone lies in the way: furthermore, by carrying one of the walls of the Cross-Course in the level or adit, you are almost certain of cutting all metallick veins in your way to the Mine.

When the Miners are working upon a metallick Lode, and are driving from east to west, or from west to east, they often meet with a Cross-Gossan, which, as before observed, unheads and breaks off the continuity of the Lode they work upon, by running across through it and causing a schism or rent; so that if they work ever so far in the same line or direction through the Cross-Course, they never will meet with the lost vein, because its corresponding part is removed from its true site and position by the intervention of the Cross-Course which throws it off further north or south. The Cross-Gossan intersects the Lode sometimes at right angles, and sometimes obliquely, and disorders it more or less in proportion to the bigness of the Cross-Gossan, and also of the underlie both of that and of the true course; and it is often so very intricate, that the most expert Miners are at a loss to find and discover the severed part of the true vein.

If the metallick Lode is intercepted at right angles, it is moved to the right hand a very little way, perhaps not more than



than one fathom, as in figure 2. plate 1. Thus, if they are working or driving from east to west, or contrary from west to east, and perceive the Lode is gone and the Cross-Course fully apparent, then they cut through the Cross-Course, and so turn house as they call it, or, in other words, they drive north or south, making a right angle almost with their former drift or working on the metallick Lode; and thus they work till they find the lost or adverse part again, or till they think they are gone too far, and that the Lode is thrown the other way; then they face about and drive the other way, which seldom disappoints their expectation of cutting the true Lode again. By certain experience this is the only method of discovering the metallick Lode, provided it is only removed at the same depth in which you lose it. This will best appear by considering figure 1. plate 1. Let the Lode E and W represent a vein intersected and thrown out of its true plane of direction by the Cross-Gossan N S, supposing the Miners are working from E to W; then, when they come from E to B, they will lose their Lode, and meet with the Cross-Course; in cutting of which quite through, and then driving to C, they will meet with their metallick Lode afresh to the right hand. The converse of this proposition is easily demonstrated; for if we suppose they are driving from W to E, then, when they come from W to C, they will lose the Lode, and meet with the Cross-Gossan; but in cutting through it, and so driving to B, they will find the metallick Lode again, to the right hand as before.

The pointing also of a rib or string of the true Lode, if carefully observed, will inform them to which side or hand the other part is removed; as will also what they call a Scrowl of the true Lode in the Cross-Gossan: therefore none but wary cautious Miners should be suffered to work in an end or stool of Ore, when it is thought to be near a Cross-Course, who by observing every string or branch of the metallick Lode, at the place of incidence, may judge which way it is thrown, and seek for the lost part of the Lode accordingly. This interruption by a Cross-Gossan at right angles, is most common, and attended with least difficulty; but when the interruption happens at oblique angles, the Lode is not easily recovered. The general rule, however, stands thus; when the Cross-Course runs obliquely N E and S W (north east and south west) it moves the metallick Lode to the right hand, as in figure 3. plate 1. on the other side of the Cross-Gossan; but if it runs very obliquely S E and N W,



N W, it sometimes removes to the left hand on the opposite side of the Cross-Goffan, as in figure 4. plate 1.

An explanation of the first figure in plate 1, is sufficient to convey an idea of the horizontal disorder or interruption of Tin and Copper Lodes, by the intervention of Cross-Goffans. The disorder imputed to real cross unmetallick Lodes, is solely horizontal, either rectangular, or oblique, and the true Lode is never elevated or depressed thereby as in Course-Flookans or Slides and parallel Lodes of a contrary inclination.

Cross-Goffans not only move Lodes out of their places, and true point of direction, but they disorder them sometimes so as to break and divide them into lesser ribs or branches; so that Miners often follow the wrong branch to their great detriment and disappointment: these also, or rather the hardness of the adjoining ground, sometimes occasion a deflexion or turning in the Lode, which we call an Elbow, whereby it deviates more or less from its true direction.

In the center, or on either of the walls of these Cross-Goffans, there is always a clayey substance, called the Flookan of the Course, not unlike the pith of vegetables; which, though it be no more than a finger's breadth, effectually dams up the water from circulating from one part of the metallick Lode, to the other that is severed by the Cross-Course; insomuch, that the two parts of the same vein may be worked to any different depth, without being at all annoyed by the water thus separated by the smallest Flookan: or however quick the water may be on one side, the other may be safely worked without fear of interruption from the water of the other side; which is a great advantage in Mining, and therefore, under certain circumstances in some Mines, they are very careful not to penetrate through this natural dam, lest they lose their Mine by an inundation of water. We may venture to add our opinion, that we owe many of our fountains and springs on the surface of the earth, to these cross veins; for the circulation of the water brought by innumerable springs into the larger veins being stopt by these cross Lodes, it bubbles up when favoured with a suitable situation in the surface.

Near to a Cross-Course, the true Lode, or the diverged branches thereof, are generally rich for Metal; because the water, whether impregnated little or much with Mineral or metallick



metallick particles, meeting with an obstruction at that place, if the nidus is at all disposed for the decomposition of the suspended Mineral, it will consequently be deposited immediately there, by means of its obstruction, rest, and continuance in that particular place. In some instances, however, one part of the Lode may be rich home to the Cross-Course, and its corresponding segment poor and barren: the one part will be tender and feeding for Ore, and its adverse will be hard and unpromising.

It would be difficult to conceive, how the broken parts of a vein, which in all probability were once united, should be of such different qualities at the point of intersection, except for the reason before given why they should be rich at such places; for it is easy to imagine, that water may be strongly or weakly impregnated with mineral particles on either side of the obstruction through which it has no intercourse, and therefore must be differently saturated, according as the neighbouring strata by their sterility or copiousness of mineral principles may implicate that element. I beg leave to observe, that these facts, and my theory in consequence of them, are to me coincident proofs in support of my opinion of the origin of Metals and Minerals.

Because the Cross-Gossans, or Cross-Flookans, run through all veins of opposite directions, without the least interruption from them, but, on the contrary, do apparently disjoint, and dislocate all of them; it seems reasonable to conclude, that the east and west veins were antecedent to cross veins; and that some great event, long after the creation, occasioned those transverse clefts and openings. But how, or when, this should come to pass, we cannot presume to form any adequate idea; unless the reader will admit the following scriptural and philosophical account of the deluge, as a probable solution.

The instrumental causes of the deluge, were “the broken  
“fountains of the great deep, and the rain which poured from  
“the windows of heaven.” Now Mr. Whiston shews from several remarkable coincidences, that a comet descending in the plane of the ecliptick towards its perihelion, passed just before the earth on the first day of the deluge; the consequences whereof would be, first, that this comet, when it came below the moon, would raise a prodigious, vast, and strong tide, both in the small seas, (which, according to his hypothesis, were in the antediluvian earth, for he allows of no great ocean there, as



in ours) and also in the abyfs which was under the upper cruft of the earth ; and that this tide would rife and increafe, all the time of the approach of the comet towards the earth. By the force of which tide, as also by the attraction of the comet, he judges, that the abyfs muft put on an eliptick figure, whose furface being confiderably larger than the former fpherical one, the outward cruft of the earth, incumbent on the abyfs, muft accommodate itfelf to that figure, which it could not do while it held folid and conjoined together. He concludes, therefore, that it muft of neceffity be extended, and at laft be broke, cleft, and fiffured, by the violence of the faid tides and attraction ; out of which clefts or fiffures, the included waters iffuing were a great means of the deluge ; this answering to what Mofes fpeaks, of “ the fountains of the great deep being broke “ up.” To remove this vaft orb of waters again, he fupposes a mighty wind to have arofe (“ God made a wind to pafs over “ the earth, and the waters affwaged. The fountains alfo of “ the deep, and the windows of heaven were ftopped, and the “ waters returned from off the earth continually”) which dried up fome, and forced the reft into the abyfs again, through the clefts or fiffures by which it came up ; only a large quantity remained in the alveus of the great ocean, &c. He has fince proved, that there was actually a comet near the earth at that time, viz. the fame great comet which appeared again in 1668. Mr. Whifton, therefore, no longer looked upon what he had advanced as an hypothefis ; but has republiſhed it in a particular tract, entitled “ The Cause of the Deluge demonſtrated.”

To whatever active caufe we may attribute the completion of fo great a phenomenon, we are nevertheless certain from the word of God, and natural obfervations, diſtinct from philoſophical enquiries, that the waters of the great deep were broken up, the hills in the ocean were elevated, the mountains of the land were funk, and the earth was variously rent and torn afunder. When thoſe ſchiſms were made, it is probable, the earth was wrung with contortions to the right and to the left, and reeled to and fro like a drunken man, whereby the continuity of veins in the earth were divided and ſeparated to ſome diſtance afunder, and eventually cauſed thoſe chafms and fiffures called Crofs-Courſes ; which partly by the return of the waters into the great abyfs from whence they came up, were filled with the looſe contiguous Earth and Stone within the vortex of the miſtifier of God’s vengeance ; and partly by the petrifying agglutinating properties that are inherent in waters circulating through



through the bowels of the earth. Indeed it is probable, that the greatest part of the contents of those contra fissures, which are only obvious and proximate to our shallow researches, are produced by the petrifactive quality of water; for they consist of a large proportion of debased Crystal, a branch or pith of clay, and a yellow or red ochreous earth, which gives it the name of a Gossan. The first is a petrification; the second is the finer parts of the strata squeezed out by the compression and reconsolidation of the earth, if I may be allowed the expression; and the last, is that spume or ochre, which continually oozes through the pores of mineralized strata, as we see on the sides of every drift and adit under-ground.

When two metallick Lodes near each other, do not run parallel in their course or line of direction, but make an oblique angle, they must necessarily meet together; and if they are both rich and inclinable to produce Ore, they commonly yield a body of it at the angle of incidence, or, as the Miners say, where the Lodes elbow each other: but if the one Lode is poor, and the other rich, then they are both either enriched or impoverished by their conjunction; and it is uncertain which will happen. After some time they will strike off again, and each continue its former direction, distinct though near to the other: but there are some very few exceptions to this, both continuing sometimes united.

When the Miners are working along on the course of a Lode, ever so good, and they find it separate and diverge into branches or strings, it is a great sign of its poverty, in that place where it is so disordered; but, on the contrary, if they are driving on branches of Ore, and they find them embodying or coming together, as they work on the course of the Lode, it is promising.

There are also branches from another quarter, which instead of being within, are without-side the walls of the Lode, in the contiguous strata or country. These branches often come into the Lode either transversely or obliquely, to its line of direction. Now, if these branches or strings are alive, or impregnated with Ore, and also if they underlie faster than the Lode, then they are said to overtake or come into the Lode, and to feed where they come into it; but if the branches do not underlie faster than the Lode, then they are said to go off from it, and thereby starve and impoverish it: yet it is difficult to conceive a right  
notion



notion of these kind of branches, without ocular demonstration; neither are these nor any other indications of the fruitfulness or sterility of a Mine, entirely to be depended on; for many Mines which have no good symptoms at first, do nevertheless prove rich; others again, which seem exceeding hopeful, alter for the worse; so that there is no certainty how a Mine will answer till it is tried in depth: however, as it is not prudent to neglect an adventure of a promising aspect; so also it is very imprudent to expend much money on a Lode, which wants encouraging marks of making a profitable Mine.

If a man is working downwards in depth in a Mine, then every branch he meets with is said, by the Miners, to be coming into the Lode; on the contrary, if he works upwards towards the surface, then every branch he meets with is said to be going off from the Lode: now, this is like taking the same thing in two different lights; for at this rate the same individual branch may be said to go into or proceed from the Lode, according to the position the Miner works in. I think it will be most intelligible to the reader, to say, that those branches, which come in on the hanging wall of the Lode, are going off from it; and those which come in through the underlying or lower wall, are properly those branches coming into the Lode, enlarging or enriching it with such Ores as the branches contain; and it is very notorious, that Lodes are oftentimes enriched by branches coming into them, of the size of an inch in thickness, or under.

Lodes are frequently so squeezed and compressed in hard compact strata, that they are not an inch wide; yet if they be alive, that is, if they have a solid string or leader of Ore, they often prove well in further pursuit; for by following the rib or leader, they may chance to come into a more tender ground, or less compact strata. So if branches or leaders of Ore widen in driving on them, or if they widen in depth, either of these is encouraging; but if the branches lie flat or horizontal, and not inclining downwards, they bear no good aspect. A Mine, however, is not immediately to be given over for a small discouragement, because, on spending ground, or working on the Lode, it may alter again, and reward the patience of the adventurers.

Small Lodes of Tin but three inches wide, are worth the working, when they are rich, clean, solid, and in good feasible ground. Also Copper Ore Lodes of six inches breadth, when they



they are solid, and are clean from waste, in fair ground will pay very well for the working. Some of our greatest Mines have had exceeding large veins; and sometimes several very small veins near together, but rich in kind, clean, and in good working ground or strata, consequently very profitable.

Besides this natural inosculation of veins, and their ramifications, we have those which frequently pass through all others except Cross-Gossans, and are called by the name of Contras. Such Lodes direct east and west, more nearly than any others; and, therefore, in their course run through many other Lodes, intersecting them at very oblique angles. If a Contra-Gossan impregnated with Copper, meets with its like, they generally make a Gulph of Ore at the place of intersection; but if it takes its course through a Scovan Lode, it mostly damages, impoverishes, and disorders the Scovan.

All veins crossing each other, may be termed Contras in respect of each other, as their courses are in opposition; but from the best information I can procure, all those Gossans which are direct east and west, run through every other Lode like Cross-Gossans, but do not disorder them in the same manner: therefore, I chuse to fix the name of Contra, vulgarly called Caunter, to these direct east and west Lodes, of whose direction and fertility the great Huel Virgin is one notable instance. It is very observable, that almost all Gossans take their course through Tin or Scovan Lodes, and from that circumstance have the names of Master Lodes: hence we have abundant reason to conclude, that all the fissures of Scovan or Tin Lodes were coeval with the creation; and that the fissures of Gossan Lodes, of every sort and kind, have been formed since the creation; and it is apparently so from the circumstances before mentioned, for, the Lode which separates and goes through another, must have been formed subsequent to that which it divides and passes between.

In the next place, I shall take notice of Lodes that meet in their underlie; as two Lodes are sometimes known, in running a parallel course east and west, to take a direction downwards or underlie towards each other, the one north, the other south, and so make considerable alterations for the better, or the worse: for if two neighbouring Lodes do underlie against each other, they must then meet in depth; and if both are prone to Ore,

E e

there



there are great hopes of a quantity thereof when they meet ; but if one be rich, and the other poor, it is uncertain how they will prove at their junction : yet this case seems rather more promising, than when two Lodes meet shallow, for this reason, because the Ore generally happens at some depth ; but if they are differently impregnated, that is, if the one is a Tin Lode, and the other a Copper Course, a disorder always ensues, for the Gossan in that case occasions an Elevation, Leap, or Heave of the Tin Lode ; but if two Gossans meet thus upon the underlie, they will mutually incorporate and pass through each other, or perhaps strike off from each other, and both take a contrary underlie for some depth, and may be variously rich or poor for Copper, as their niduses may be variously mineralized.

Now if two Lodes are very near together, and underlie both one way, but the hinder Lode more or faster than the other, which seems to go from it ; when the case is thus, the hinder Lode will overtake the other in depth, and associate with it. But if two Lodes near each other, underlie alike, and if the hinder one doth not underlie faster than the other, they will never meet, unless they form an angle in their course east in west. By the hinder Lode, I mean that which, by its underlie, follows another underlying Lode ; as when two east and west Lodes do underlie north ; of consequence the most southern of the two is the hinder one, because it follows the northern on the underlie.

The most considerable disorder which Lodes are liable to in Cornwall or elsewhere, is what is termed a Start, a Leap, or a Heave by a Slide or Course-Flookan. It so happens, that in sinking upon a Tin or Copper Lode, they are suddenly at a loss for the continuation of the Lode downwards. In one day's time, in the working a rich Lode of Tin, they are thus disappointed, and have no further sign of a Lode to work upon ; but at the extremity of their working down the Lode in depth, they may perceive a vein of Flookan or clayey-matter, underlying in opposition to the Lode they were sinking upon. This Flookan may be half an inch, or a foot, in thickness ; it may be even more or less : but as it is, whenever the Miners are foiled of the Lode they were working, or have lost it in this manner, they conclude and say they are " cut out by a Slide." Now I apprehend the heave is, *cæteris paribus*, in proportion to the size of the Flookan or Slide, which may vary according to the angle of subsidence ;



subsidence; that is, if the subsidence is great or small, so may the Flookan be more wide or narrow, and the Elevation or Depression of the fractured Lode be more or less up or down; therefore some Lodes may be heaved up some fathoms, and others only so many feet. Be it little or much, there is an infallible rule whereby they may recover the Lode again, as the reader will readily apprehend by the following section in the plate.

Tin Lodes are not only heaved by Flookans, called Slides; but they are so in the very same manner by opposite underlying Gossan Lodes, which are sometimes impregnated and sometimes not: but those heaves are generally more distant, and higher up, in proportion to the size of the Gossan, according to the position laid down before. This fracture of the Lode by a Gossan Slide, is what they call, in other parts of England, "A trap up, or a trap down by a ridge;" which, in Somersetshire, is defined, "A parting of Clay, Stone, or Rubble;" as if the veins were disjoined and broken by some violent shock, so as to let in Rubble, &c. between them.

As we cannot make the reader readily apprehend this fracture of Lodes, without a representation of it; we have given a transverse section of Goon Lâz and the Pink Mines in St. Agnes, taken from an actual survey. Here it appears, that the Tin Lode underlies north, and the Gossan Slide south. At the junction of the two Lodes at G, the Tin Lode is cut out by the Slide, and heaved up to H, twenty-two fathoms in perpendicular height, nineteen fathoms horizontally north, and thirty diagonally, by the underlie of the Gossan; so that if a shaft had been sunk between C and D, no Tin Lode could have been cut or discovered: but, by the shaft B, the same Lode is cut again in the Pink Mine at I, a small depth under the adit level, and not very far below the south wall of the Gossan. The adit in this place, seems to give the Miners some direction, how and where to put down their shaft B: but when the same Lode was fractured, and heaved again from K to E, their next care was to drive a drift L from K to M, where they cut the Lode again, and rose upon the back of it up to the north wall of the second and smaller Gossan 2 E; and likewise sunk upon their Tin Lode down to N, where it was again fractured by a third and smaller Gossan 3 O, and heaved about nine feet; cut once more at P, and is now working by virtue of a water engine in the shaft Q Q, which



which draws the water out of the bottoms of the Mine to the adit, from whence it is discharged into the sea half a mile off.

The common method for recovery of a Lode, when thus disordered by a Slide or Gossan, is exemplified in the drift L driven from K to M; so that almost always, when it is heaved, they drive immediately from the angle of incidence, from the bottom wall of the Slide, be it either north or south, until they find the frustum of their former Lode again: that is, (as in the case before us) if the metallick Lode underlies north, the Slide must underlie south, and of consequence the drift for recovery of the lost part must be north; and so vice versa.

In some cases they find the Lode again by sinking a shaft from grafs, which answers a double intention; for a shaft must be had, whenever the Lode is cut by any other method, in order to work the same effectually: in the Pink, however, if a shaft had been sunk between C and D, or E and F, they never could have cut the Tin Lode again, but in fact would have missed every remove of it. Again, if they had driven immediately from the place of intersection G, they must have driven sixty fathoms north, before they could cut the Lode again; which in all likelihood would have been so tedious and expensive, that they would have deserted their pursuit before they had driven half the ground, and entirely missed the intermediate heave K H. Nevertheless, a discerning Miner, in either case, might find the intermediate heave; for if a shaft had been sunk between C and D, the first great Gossan I must have been sunk through perhaps at T, and the same continued down through the next Gossan at V. Thus, by having sunk through two Gossans, the experienced Miner concludes the first heave to be situated between them, and rises in the back to cut it, if air and other circumstances are favourable; or, which is better, will sink a shaft B. The same proposition holds good in driving; for if a drift is driven from G to V, both the Gossans must be cut; whence it is easy to conclude, that there must be a heave between them. It is very clear, that none but the most observant experienced Miners are proper for this work: incautious injudicious persons may easily sink or drive through a Slide, and be totally ignorant of the matter; for they are sometimes not an inch wide, and are scarcely discernible; so that it is a matter of the utmost nicety, and most accurate enquiry, to recover a Lode when it is cut out by a Slide, &c.

From



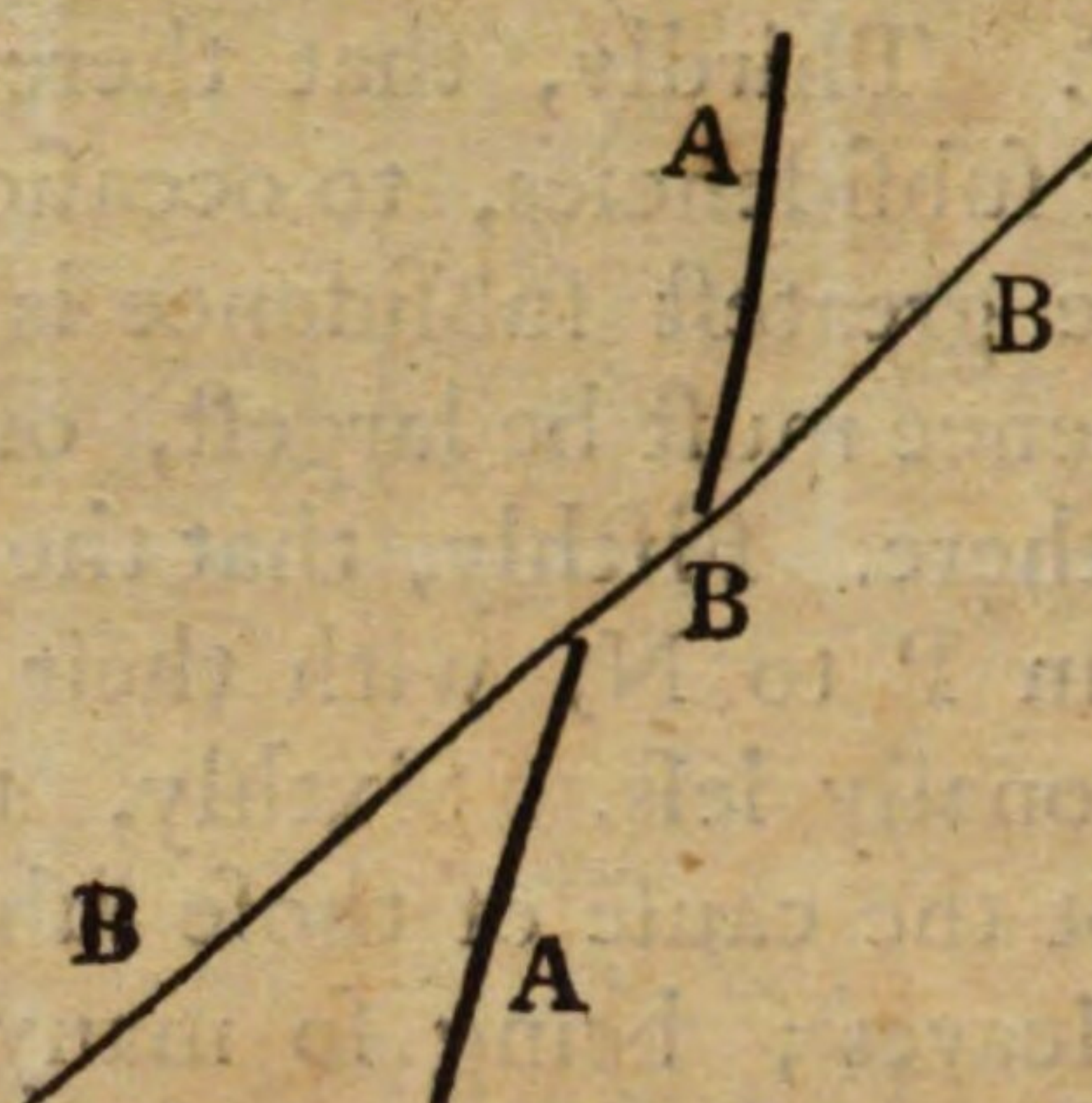
From what has been advanced, these corollaries may be drawn: First, that all those heaves are fractured parts of one and the same Lode, which were formerly united; especially as they consist of the same kind of Tin, make the same angle with the horizon, and are all of one breadth. Secondly, that this fractured Lode was formed in the fissure before it became inclined or fractured in this manner; for G was joined to H, K to E, and N to P. Thirdly, that there must have been three successive different subsidencies, to occasion those three fractures. Fourthly, that the greatest subsidence is from C to G; and the Gossan of consequence must be largest, on account of the greater rent or separation there. Fifthly, that the other subsidencies from E to K, and from P to N, with their Gossans, are, *cæteris paribus*, proportionally less. Sixthly, that those Gossans are the effect, and not the cause of those subsidencies, which are so reversely called Heaves; being so many rents or fissures filled up in length of time with Clay, Rubble, Ochre, &c. from the contiguous strata.

Moreover, it is particularly remarkable, that the surface and strata carry many corroborating proofs of sundry subsidencies at this place; for, at the very spot, there is a sudden steep descent, which forms a narrow deep coomb, or valley. Half a mile further north, I have remarked the sea cliffs, where instead of the strata dipping towards the sea, they are inclined to the south, towards the land, and make an angle of nearly forty-five degrees with the horizon. Further off, at a greater distance in the sea, are two huge rocks, which look like small islands, and are always above water equally high with the main land: whence I have reason to conclude, that these rocks were once a part of the continent; that the coomb was anciently not so deep as now it is; and that the contiguous strata have been unfooted and sunk downwards, not only once, or twice, but many times.

There is another fracture and remove of Lodes, dependent on the same cause with the foregoing, which is more truly and commonly called the being "cut out by a Slide." This Slide does not underlie in opposition to the metallick Lode, as that at Goon-Lâz; but, on the contrary, it comes in behind the Lode, which it interrupts by underlying faster. This Slide is composed of a fine unctuous gray or white clay; is seldom six inches big; and the remove is rarely six feet distance.



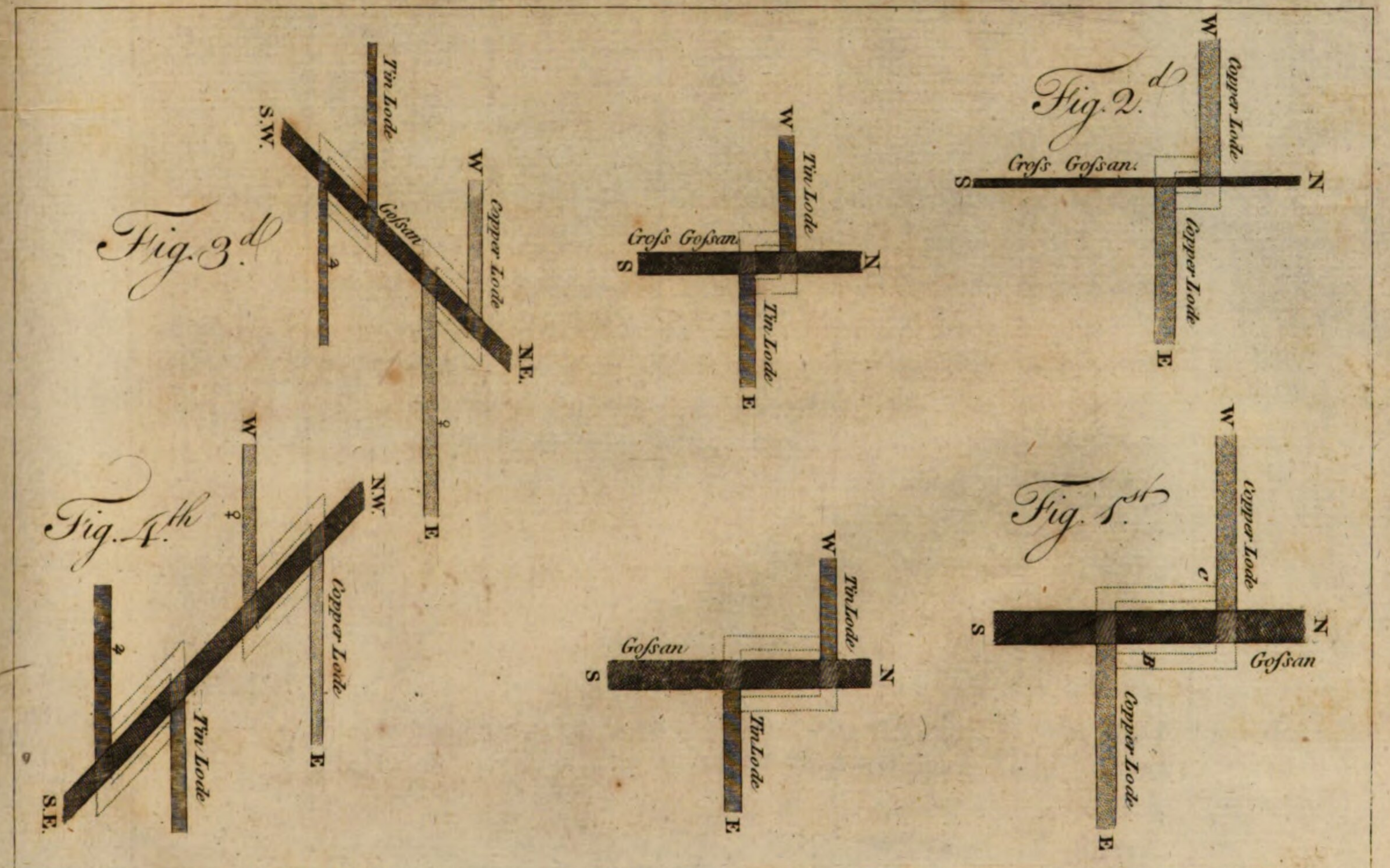
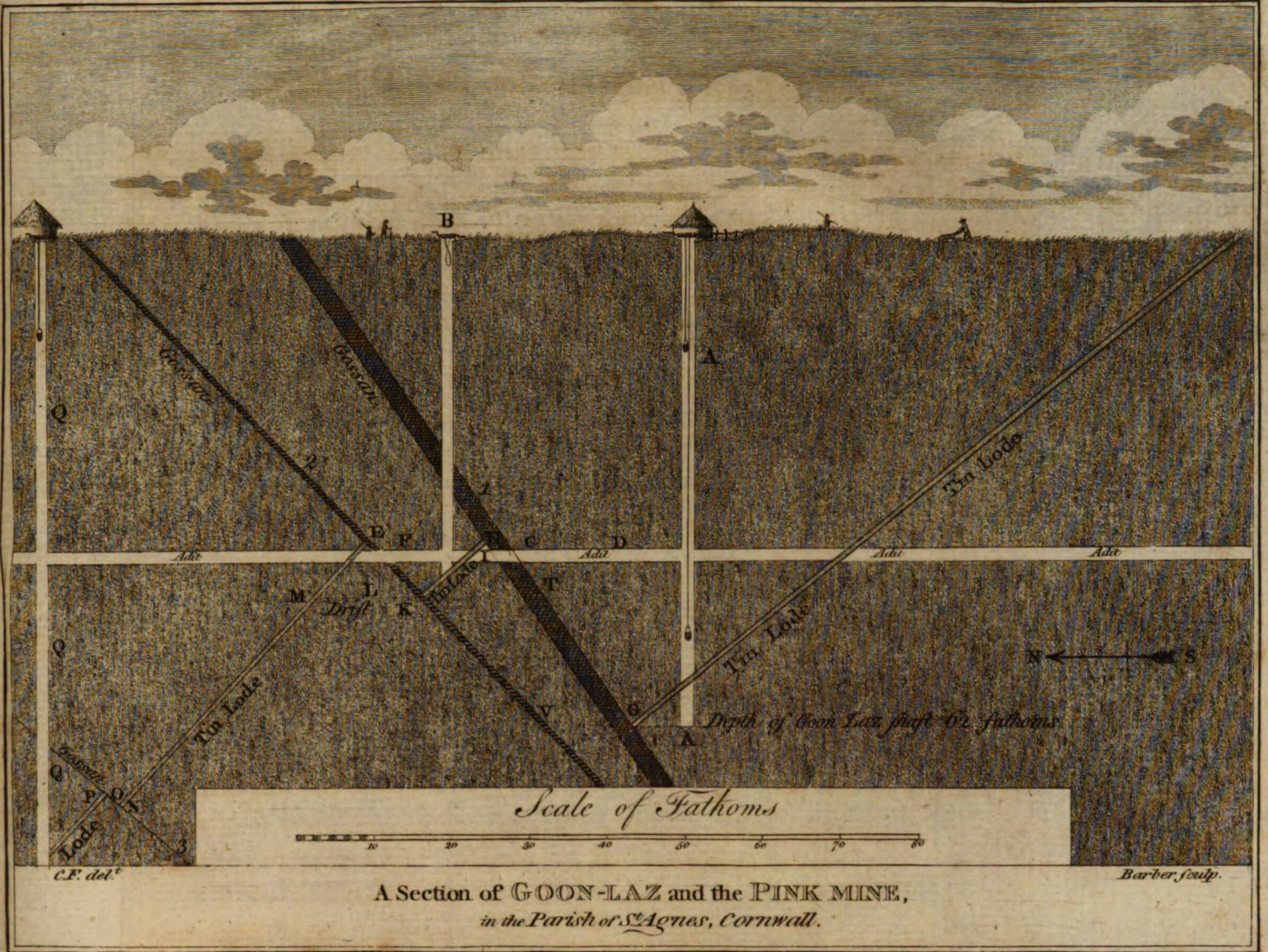
distance. Let A A represent the true or metallick Lode, and B B B the Slide, and the fracture and remove will be seen at one glance; whence the reader may judge for himself, how expeditiously and certainly the metallick Lode may be recovered.



Moreover, it is particularly remarkable, that the surface and that every many corresponding brooks of lumpy topographies at this place, for at the very spot, there is a sudden steep descent, which seems a narrow deep comb, or valley. Half a mile further north, I have remarked the sea cliffs, where instead of the steep dipping towards the sea, they are inclined to the land, towards the land, and make an angle of nearly forty-five degrees with the horizon. Further off, at a greater distance in the sea, are two large rocks, which look like small islands, and are always above water equally high with the main land: whence I have reason to conclude, that these rocks were once a part of the continent; that the comb was anciently not so deep as now it is; and that the contiguous strata have been unroofed and sunk downwards, not only once, or twice, but many times.

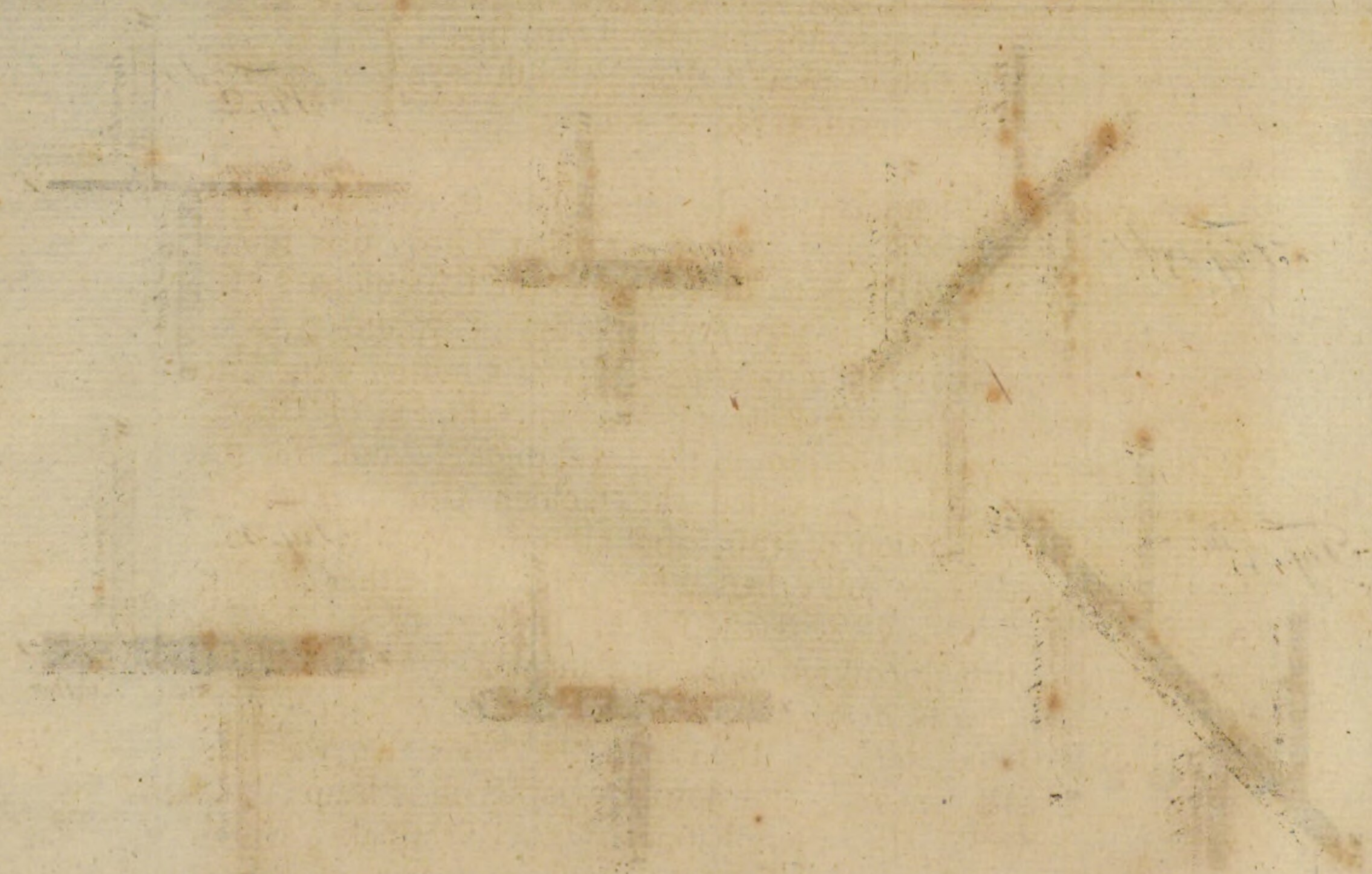
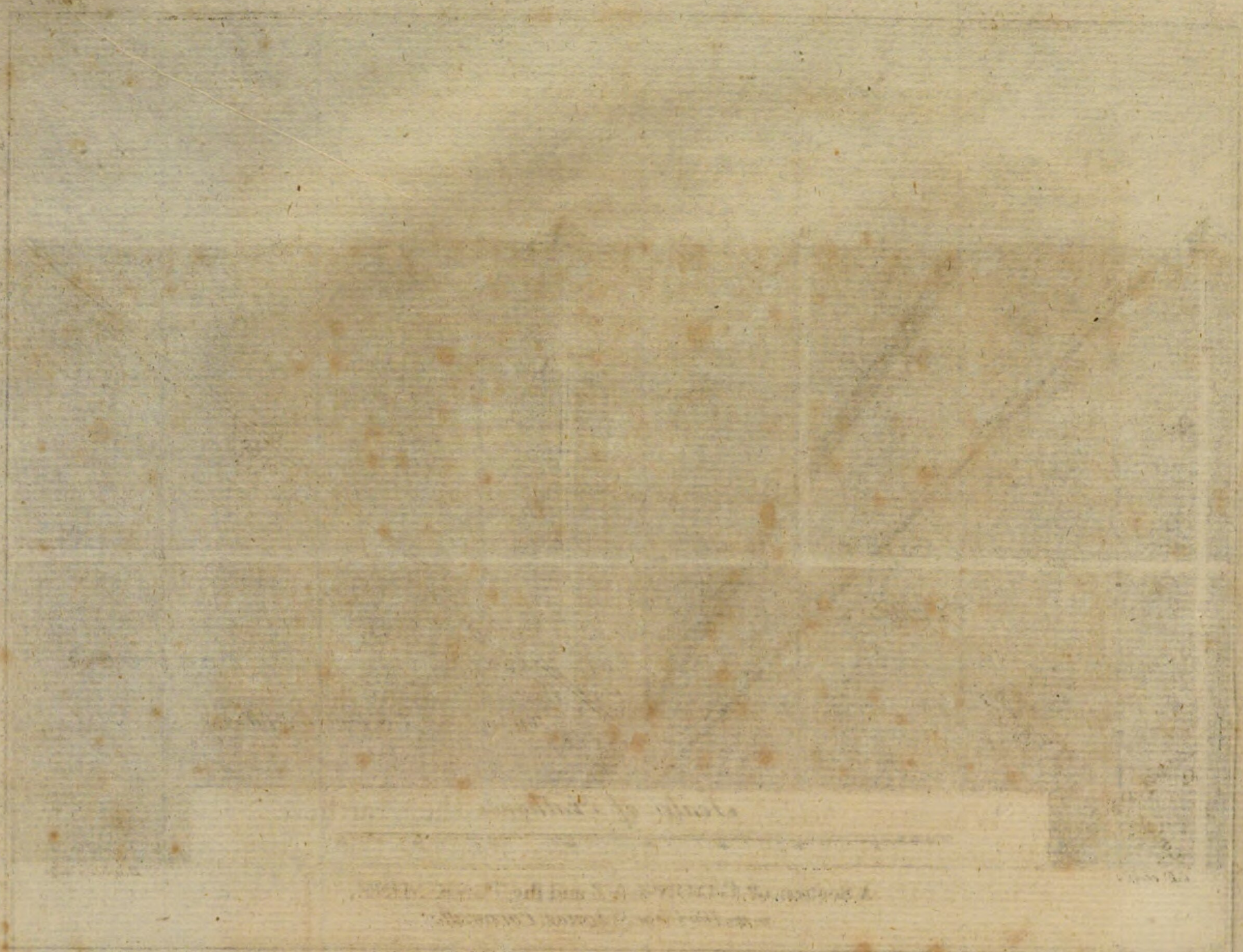
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To Sir William Lemon of Carden Bar<sup>t</sup>. M.P.  
for the County of Cornwall  
This **PLAN** and **SECTION** Engraved at his Expence  
is most gratefully Inscribed by W<sup>m</sup> Pryce.





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## B O O K III.

### C H A P. I.

Of the various Methods of discovering Mines.

**L**UCRETIVS, who ascribes the first discovery of Metals to the burning down of woods, says, that the heat of the flames melted the Metals, which were dispersed here and there in the veins of the earth, and made them flow into one mass :

Whatever 'twas that gave these flames their birth,  
Which burnt the tow'ring trees, and scorch'd the earth;  
Hot streams of Silver, Gold, and Lead, and Brass, }  
As nature gave a hollow, proper place,  
Descended down, and form'd a glitt'ring mass. }  
'This when unhappy Mortals chanc'd to spy,  
And the gay colour pleas'd their childish eye; }  
They dug the certain cause of misery.

Cadmus, the Phenician, is, by some, said to have been the first who discovered Gold; others say, that Thoas first found it, in the mountain Pangæus in Thrace: the Chronicon Alexandrinum, ascribes it to Mercury, the son of Jupiter; or to Pifus, king of Italy, who quitting his own country went into Egypt; where, after the death of Misraim, the son of Cham, he was elected to succeed him in the royal dignity, and, for the invention of Gold, was called the Golden God. Æschylus attributes the invention of this, and all other Metals, to Prometheus: and there are others who write, that either Æacis, whom Hyginus calls Cæacus the son of Jupiter, or Sol the son of Oceanus, first discovered Gold in Panchaia. Aristotle says, that some shepherds in Spain having set fire to certain woods, and heated the substance of the earth, the Silver that was near the surface of it, melted, and flowed together in a heap; and that a little while after there happened an earthquake, which cleaved the earth, and disclosed a vast profusion of Silver.

This



This is confirmed by Strabo, lib. iii. and Athenæus, lib. vi. who say, that the Mines in Andalusia were discovered by this accident. Cinyra the son of Agryopa, first found out the Brass (Copper) Mines in Cyprus; and the discovery of Iron Mines Hesiod ascribes to those in Crete who were called Dactyli Idæi: and Midacritus was the first man that brought Lead (Tin) out of the island Cassiteris. (Lucretius, Pliny, Polydore Virgil).

We shall close this ancient account of the first discovery of Metals, with the following lines from Dr. Garth's Dispensary.

Now those profunder regions they explore,  
Where Metals ripen in vast cakes of Ore.  
Here, fullen to the sight, at large is spread,  
The dull unweildy mass of lumpish Lead;  
There, glimmering in their dawning beds, are seen  
The more aspiring seeds of sprightly Tin;  
The Copper sparkling next in ruddy streaks,  
And in the gloom betrays its glowing cheeks.

Mines have been often discovered by accident, as in the sea cliffs, among broken craggy rocks, or by the washing of the tides or floods; likewise by irruptions and torrents of water issuing out of hills and mountains; and sometimes by the wearing of high roads. Another way of finding veins, which we have heard from those whose veracity we are unwilling to question, is by igneous appearances, or fiery coruscations. The Tanners generally compare these effluvia to blazing stars, or other whimsical likenesses, as their fears or hopes suggest; and search, with uncommon eagerness, the ground which these jack o'lanthorns have appeared over and pointed out. We have heard but little of these phenomena for many years; whether it be, that the present age is less credulous than the foregoing; or that the ground being more perforated by innumerable new pits sunk every year, some of which by the Statutory laws are prohibited from being filled up, has given these vapours a more gradual vent; it is not necessary to enquire, as the fact itself is not generally believed. The art of Mining, however, does not wait for these favourable accidents, but directly goes upon the search and discovery of such Mineral Veins, Ores, Stones, &c. as may be worth the working for Metal. The principal investigation and discovery of Mines, depends upon a particular sagacity, or acquired habit of judging from particular signs, that metallick matters are contained in  
certain



certain parts of the earth, not far below its surface. But, as ignorance and credulity are the portions of the illiterate, we have people constantly in search for Tin, where our dreaming geniuses direct them to follow after the images of wild fancy; consequently, we have a Huel-dream in every Mining parish, which raises and disappoints by turns the sanguine hopes of the credulous adventurers.

Mines are also discovered by the harsh disagreeable taste of the waters which issue from them, especially those of Copper: but this seems to be, only when the Ore is above the level at which the water breaks out; for, otherwise, it is unlikely that the water should participate of much impression or quality from the Ore that is underneath it, or untouched by it. A better expedient to find whether the water is impregnated with Copper, is to immerge a piece of bright Iron in it, for two or three days; in which time, the Iron will look of a Copper colour, provided the water is of a cupreous quality, or at least contains a certain share of vitriolick acid: further, if some Aqua Fortis be affused to a little of this water, in a clear phial, it will presently exhibit a bluish green colour, either fainter or fuller according as it is impregnated with the acid of vitriol. A candle or piece of tallow put into the same water for a few days, may be taken out tinged of a green colour.

Hoofon says, that “the first inventor of the *Virgula Divinatoria*, was hanged in Germany as a cheat and impostor:” on the other hand, Dr. Diederick Wessel Linden says, in answer to him, that “Dr. Stahl, when he was president of a chemical society in his country, published a reward of twenty-five ducats for any body that could prove who was the inventor of the *Virgula Divinatoria*.” It is impossible to ascertain the date or personality of this discovery, which appears to me of very little consequence to posterity: but perhaps we may not be far off from the truth, if we incline to the opinion of Georgius Agricola, in his excellent latin treatise *De Re Metallica*, that “the application of the enchanted or divining rod to metallick matters, took its rise from magicians, and the impure foundations of enchantment.” Now the ancients not only endeavoured to procure the necessaries of life by a divining or enchanted rod, but also to change the forms of things by the same instrument: for the magicians of Egypt, as we learn from the Hebrew writings, changed their rods into serpents; and, in Homer, Minerva turned Ulysses when old into the likeness



of a young man, and again to his former appearance: Circe also changed the companions of Ulysses into beasts, and again restored them to the human shape; and Mercury, with his rod called Caduceus, gave sleep to the wakeful, and awakened those that were asleep. And hence, in all probability, arose the application of the forked rod to the discovery of hidden treasure.

Nevertheless we find no mention made of this Virgula before the eleventh century, since which it has been in frequent use. It was much talked of in France towards the end of the seventeenth century; and the corpuscular philosophy was called in to account for it. The corpuscles, it was said, that rise from the Minerals, entering the rod, determine it to bow down, in order to render it parallel to the vertical lines which the effluvia describe in their rise. In effect the Mineral particles seem to be emitted from the earth: now the Virgula being of a light porous wood, gives an easy passage to those particles, which are very fine and subtle; the effluvia then driven forwards by those that follow them, and pressed at the same time by the atmosphere incumbent on them, are forced to enter the little interstices between the fibres of the wood, and by that effort they oblige it to incline, or dip down perpendicularly, to become parallel with the little columns which those vapours form in their rise.

The primary and most simple affections of matter, according to the great Mr. Boyle, are (1) Local Motion, (2) Size, (3) Shape, and (4) Rest. But because there are some others, that naturally flow from these, and are, though not altogether universal, yet very general and pregnant, we shall subjoin those which are the most fertile principles of the qualities of bodies, and other phenomena of nature. Those lesser fragments of matter, which we call corpuscles or particles, have certain local respects to other bodies, and to those situations which we denominate from the horizon; so that each of these minute fragments may have a particular (5) posture or position, as erect, inclining, horizontal, &c. and as they respect us that behold them, there may belong to them a certain (6) order or consecution, whereby we say, one is before or behind another; and many of these fragments being associated into one mass or body, have a certain manner of existing together, which we call (7) texture or modification. Almost all bodies, and those fluid ones that are made up of grosser parts, will have (8) pores in them: and very many bodies having particles, which, by their  
smallness,



smallness, or their loose adherence to the bigger or more stable parts of bodies they belong to, are more easily agitated, and separated from the rest by heat and other agents; therefore there will be great store of bodies, that will emit those subtle emanations, which are commonly called (9) effluvia.

Each of these nine producers of phenomena, admit of a variety scarcely credible. For not to descend so low as insensible corpuscles, (or those which are imperceptible to natural or artificial opticks, many thousands of them being requisite to constitute the size of a mustard seed) what an innumerable company of different bignesses may we conceive between the bulk of a mite, (a crowd of which is necessary to weigh one grain) and a mountain, or the body of the sun! Figure, though one of the most simple modes of matter, is capable of great varieties, partly in regard of the surface or surfaces of the figured corpuscles, (which may consist of squares, triangles, pentagons, &c.) and partly in regard of the shape of the body itself, which may be either flat like a cheese, spherical like a bullet, elliptical like an egg, cubical like a die, cylindrical like a pump, hexagonal pointed like a pyramid, or conical like a sugar loaf. And yet all these figures are few compared to those irregular shapes, which are to be met with among rubbish, &c. So likewise motion, which seems so simple a principle, especially in simple bodies, may even in them be very much diversified; and as to the determination of motion, the body may move directly upwards, or downwards, declining, or horizontally, east, west, north, or south, &c. according to the situation of the impellent body. There will likewise arise new diversifications, from the greater or lesser number of the moving corpuscles; from their following one another close, or more at a distance, &c. from the thickness, thinness, pores, and the conditions of the medium through which they move; and from the equal or unequal celerity of their motion, and force of their impulse: and the effects of all these are variable by the different situation and structure of the sensories, or other bodies, on which these corpuscles act.

Now there are, first, many bodies, that in diverse cases act not, unless they be acted on; and some of them act, either solely or chiefly as they are acted on by common and unheeded agents. Secondly, there are certain subtle bodies that are ready to insinuate themselves into the pores of any body disposed to admit their action, or by some other way effect it. Thirdly, there are bodies, which, by a mechanical change of texture,  
may



may acquire or lose a fitness to be wrought upon by such unnoticed agents, and also to diversify their operations on it, upon the force of its varying texture. All these propositions are proved from the most common, though unheeded affairs and occurrences of human life; as easily, as the polarity and magnetism of an old Iron bar taken from a church window, where it has stood upright for many centuries, is proved to derive its virtue from the magnetick effluvia of the earth.

As many deny, or at least doubt, the attributed properties of the divining rod, I shall not take upon me, singly to oppose the general opinion, although I am well convinced of its absolute and improveable virtues. It does not become me to decide upon so controvertible a point; particularly, as from my natural constitution of mind and body, I am almost incapable of co-operating with its influence; and, therefore, cannot, of my own knowledge and experience, produce satisfactory proofs of its value and excellence. I shall, however, give those accurate observations on the virtues of the *Virgula Divinatoria*, which I have been favoured with by my worthy friend Mr. William Cookworthy, of Plymouth, a man, not less esteemed for his refined sense and unimpeachable veracity, than for his chemical abilities. It is to him the publick is indebted for the late improvements in the porcelain manufactory now established at Bristol, which, under his direction, is likely to be rendered not less elegant and durable than the best Asiatick China.

His first knowledge of the rod, he says, was from a captain Ribeira, who deserted the Spanish service in queen Ann's reign, and became the capt. commandant in the garrison of Plymouth; in which town he satisfied several intelligent persons of the virtues of the rod by many experiments on pieces of Metal hid in the earth, and by the actual discovery of a Copper Mine near Oakhampton, which was wrought for some years. The captain made no difficulty to let people see him use the rod, but he was absolutely tenacious of the secret how to distinguish the different Metals by it, without which, the knowledge of its attraction is of little use: but by a close attention to his practice, the writer has discovered this, and made many other discoveries of its properties, which he is willing should be published, being fully persuaded of the great utility of this instrument in Mineral undertakings; and the reader may be assured, that he is fully convinced of the truth of what he communicates from abundant and very clear experience.

Captain



Captain Ribeira held, that rods cut from the nut or other fruit-bearing trees, were the only proper ones for this use ; and that the virtue was confined to certain persons, and those comparatively few. Agricola says, “ If the attractive power of veins does not “ turn the rod, when in the hands of some particular metallists “ or others, it is owing to some singular occult quality in the “ holder, which impedes and restrains the attractive power ; “ for since that power moves and turns the rod, in the same “ manner as the Lodestone invites and attracts Iron, it is “ debilitated and destroyed by the occult quality in the holder, “ just as garlick weakens and excludes the attractive quality of “ the magnet, for a magnet rubbed over with juice of garlick “ does not draw Iron.” But this proves to be a mistake of captain Ribeira ; for the virtue, as he calls it, resides in all persons, and in all rods, under the circumstances hereafter described.

The rod is attracted by all the Metals, by Coals, Bones, Limestone, and Springs of Water, with different degrees of strength in the following order : 1 Gold, 2 Copper, 3 Iron, 4 Silver, 5 Tin, 6 Lead, 7 Coals, 8 Limestone and Springs of Water. One method to determine the different attractions of the rod, is this : Stand, holding the rod, with one foot advanced ; put a guinea under that foot, and a halfpenny under the other, and the rod will be drawn down ; shift the pieces of money, and the rod will then be drawn towards the face or backwards to the Gold, which proves the Gold to have the stronger attraction. By trying all the subjects of the rod in the same manner, their respective attractions in point of strength will be found to correspond with the order in which I have already placed them.

The rods formerly used, were shoots of one year's growth that grew forked, as figures 1 and 2, plate 2 ; but it is found, that two separate shoots tied together with some vegetable substance, as packthread, will answer rather better than those which are grown forked, as their shoots being seldom of equal length or bigness they do not handle so well as the others, which may be chosen of exactly the same size. The shape of the rod thus prepared, will be between  $2\frac{1}{2}$  and 3 feet long, like fig. 3, plate 2. They must be tied together at their great or root ends, the smaller being to be held in the hands. Hazle rods cut in the winter, such as are used for fishing rods, and kept till they are dry, do best ; though where these are not at hand, apple-



tree suckers, rods from peach-trees, currants, or the oak, though green, will answer tolerably well.

It is very difficult to describe the manner of holding and using the rod: it ought to be held in the hands, in the position fig. 4, plate 2, the smaller ends lying flat or parallel to the horizon, and the upper part in an elevation not perpendicular to it, but 70 degrees, as fig. 4, plate 2.

Alonzo Barba directs the rod to be fixed across the head of a walking stick in form of a T, and the end which is nearest the root will dip or incline to the Mineral Ore.

The rod being properly held by those with whom it will answer, when the toe of the right foot is within the semi-diameter of the piece of Metal or other subject of the rod, it will be repelled towards the face, and continue to be so, while the foot is kept from touching or being directly over the subject; in which case, it will be sensibly and strongly attracted, and be drawn quite down. The rod should be firmly and steadily grasped; for if, when it hath begun to be attracted there be the least imaginable jirk, or opposition to its attraction, it will not move any more, till the hands are opened and a fresh grasp taken. The stronger the grasp the livelier the rod moves, provided the grasp be steady, and of an equal strength. This observation is very necessary, as the operation of the rod in many hands is defeated purely by a jerk or counter action; and it is from thence concluded, there is no real efficacy in the rod, or that the person who holds it wants the virtue; whereas by a proper attention to this circumstance in using it, five persons in six have the virtue as it is called; that is, the nut or fruit bearing rod will answer in their hands. When the rod is drawn down, the hands must be opened, the rod raised by the middle fingers, a fresh grasp taken, and the rod held again in the direction described.

A little practice by a person in earnest about it, will soon give him the necessary adroitness in the use of this instrument: but it must be particularly observed, that as our animal spirits are necessary to this process, so a man ought to hold the rod, with the same indifference and inattention to, or reasoning about it or its effects, as he holds a fishing rod or a walking stick; for if the mind be occupied by doubts, reasoning, or any other operation that engages the animal spirits, it will divert their powers from being exerted in this process, in which their instrumentality



instrumentality is absolutely necessary ; from hence it is, that the rod constantly answers in the hands of peasants, women, and children, who hold it simply without puzzling their minds with doubts or reasonings. Whatever may be thought of this observation, it is a very just one, and of great consequence in the practice of the rod.

If a rod, or the least piece of one, of the nut bearing or fruit kind, be put under the arm, it will totally destroy the operation of the *Virgula Divinatoria* in regard to all the subjects of it, except water, in those hands in which the rod naturally operates. If the least animal thread, as silk, or worsted, or hair, be tied round or fixt on the top of the rod, it will in like manner hinder its operation ; but the same rod placed under the arm, or the same animal substances tied round or fixt on the top of the rod, will make it work in those hands, in which, without these additions, it is not attracted.

The willow, and other rods, that will not answer in the hands, in which the fruit or nut bearing rods are attracted, will answer in those hands in which the others will not ; so that all persons using fuitable rods in a proper manner, have the virtue as it is called of the rod. A piece of the same willow placed under the arm, or the silk, worsted, or hair, bound round, or fixt to the top of it, will make it answer with those to whom the nut or fruit bearing rods are naturally fuitable, and in whose hands without those additions it would not answer.

All rods, in all hands, answer to springs of water.

A piece of Gold held in the hand, and touching the rod, will not only hinder its being attracted by this Metal ; but, on the contrary, the rod will be repelled towards the face. It is the same in regard to Copper as well as Gold, if the latter is held in the hand.

If Iron is so held, the rod will be repelled by that means. If any of the white Metals, viz. Silver, Lead, or Tin, be held in the hand, the rod will not be attracted, but repelled by all those Metals. It is the same with Limestone, Bone, and Coal. And, vice versa, if a person with whom the rod doth not naturally operate, holds a piece of Gold in his hand, the rod will then be attracted by Gold and Copper. The same holds good with all subjects of the rod.

On



On these properties of the rod, depends the practice of distinguishing one Metal or subject from another. There is, however, another way of distinguishing, drawn from the same principles, but much more certain and ready than the former; and that is by preparing rods, that will only operate on Gold and Copper, Iron, the white Metals, Coals, Bones, and Limestone.

Thus, if a rod is wanted for distinguishing Copper or Gold, procure filings of Iron, Lead, and Tin, some leaf Silver, Chalk in powder, Coal in powder, and rasped bones: let a hole be bored with a small gimlet in the top of the rod; then mix the least imaginable quantity of the above ingredients, and put it in the gimlet hole with a peg of the same wood with the rod, when it will only be attracted by what is left out, viz. Gold and Copper.

In preparing a rod for distinguishing the white Metals, leave out the Lead, Tin, and leaf Silver, and add Copper filings to the other ingredients; and so of every subject by which you would have the rod attracted, the respective filings, or powder, must be left out of the mixture, which is to be put into the hole, at the top of the rod. As for Coal and Bones, they may be omitted in the distinguishing rods that are used in Cornwall, for obvious reasons: but it is necessary to put in the Chalk or Lime; for though there is no Limestone in the Mining part of the county, yet there are abundance of strata that draw the rod as Limestone; for the distinction of a dead or a live course, holds as well in regard to Limestone, as to the Metals. This, however paradoxical it may appear, is a truth easily to be proved; and it is one axiom in the science of the rod, that it makes no distinction between the living and dead parts of a course. Like the Lodestone, it only shews the course, leaving the success of the undertaking, to the fortune, skill, and management of the Miner; as the Lodestone doth that of the voyage, to the fortune, ability, and prudence of the mariner and merchant.

It is advisable for young beginners to make no experiments but about actual Lodes, where the backs of them are known by the Miners; or else nigh the sea, where a Lode being discovered, they may trace it to the cliffs, and will be sure to find it.

The



The rod being guarded against all subjects except that which you want to discover, as Tin and Copper for example; walk steadily and slowly on with it; and a person that hath been accustomed to carry it, will meet with a single repulsion and attraction, every three, four, or five yards, which must not be heeded, it being only from the water that is between every bed of Killas, Grouan, or other strata. When the holder approaches a Lode so near as its semidiameter, the rod feels loose in the hands, and is very sensibly repelled toward the face; if it is thrown back so far as to touch the hat, it must be brought forward to its usual elevation; when it will continue to be repelled till the foremost foot is over the edge of the Lode: when this is the case, if the rod is held well, there will first be a small repulsion towards the face; but this is momentary; and the rod will be immediately drawn irresistibly down, and will continue to be so in the whole passage over the Lode; but as soon as the foremost foot is beyond its limits, the attraction from the hindmost foot; which is still on the Lode, or else the repulsion on the other side, or both, throw the rod back toward the face. The distance from the point where the attraction begun, and where it ended, is the breadth of the Lode; or rather, of a horizontal section of the bryle or back just under the earth. We must then turn, and trace it on obliquely, or in the way of zig zag, as far as may be thought necessary.

In the course of this tracing a Lode, all the circumstances of it, so far as they relate to its back, will be discovered; as its breadth at different places, its being squeezed together by hard strata, its being cut off and thrown aside from its regular course by a Cross-Gossan, &c.

In order to determine this, it will be necessary, that some one present should either cut up a turf, or place a stone at the places where the rod began, and on the other side where it ceased to be attracted.

The draughts, in plate 2, of Veins parted and proved according to the above directions, may make this sufficiently clear. The dots represent the turf or stone; and the zig zag, the line in which the operator moves in pursuing the Vein. Fig. 5, is a Lode going on east and west regularly, with the repulsion expressed by the lines north and south on each side. Fig. 6, is a Lode squeezed by a hard strata in some places almost to a string. Fig. 7, is a Lode cut off by a Cross-Gossan, wherein the



method for discovering of the separated part is obvious to any intelligent Miner, upon the same line at grafs with the rod, as underground with the Pick and Gad.

In tracing a Lode for a considerable length, there is no necessity for the zig zag traversing, but it may be done according to the delineation fig. 8, wherein the operator endeavours to keep the middle of the Lode, and turns when the rod, by its repulsion, intimates that he is got beyond it.

If the rod is well held, its motion is surprisngly quick and lively: nothing is necessary, but to keep the mind indifferent, to grasp the rod pretty strongly, and steadily; opening the hands, and raising the rod with the middle fingers, every time it is drawn down. If the rod is raised and replaced without opening the hands, it will not work.

The discovery of the Metal a Lode is naturally disposed to contain, is very easy: try it with a distinguishing rod; if it attracts it, it contains the Metal that is left out of the mixture at the top of that rod; if it draws more than one rod, the Lode is compounded of those Metals.

Copper Lodes generally draw the rod distinguishing Iron, because of the ferruginous Gossan contained in them; but Tin Lodes frequently draw none but their proper rod, unless Gal, which is a kind of Iron Ore, is intermixed.

It has been said above, that the rod makes no distinction between the living or dead parts of a Lode: though this is invariably true, yet this instrument is of great use, as it helps us to trace any known Lode from the spot where it is wrought, through other people's lands who might be willing to try it.

If the Lode is alive to its top, or as it is usually phrased by the Tinnerns, To Grafs; more work may be done in the way of discovery with the rod in a quarter of an hour, than by the usual methods in months, as a person has nothing to do, but to open the Lode immediately at grafs, and discover its size and underlie, which may be done at a trifling expence.

The discovery of Cross-Gossans by the rod, is a property which may be usefully employed in Mining, particularly in driving



driving adits, as the driving an adit through a Cross-Gossan is much easier than through the country.

In seeking for water by the rod, no notice is to be taken of those single attractions of the rod which are occasioned by the commissures or crevices (called Cases of Water by the Tinnerns) between the courses or distinct runs of Killas; but a vein must be found, which answers to the rod as a Metal, and if this is sunk unto a proper depth, a good quantity of water will be discovered.

It may not be amiss to close this little essay on the Virgula Divinatoria, with some few striking instances of courses, that have been cut by means of it in Cornwall.

A quantity of grain Tin having been found in the pond at Heligan, the seat of the reverend Mr. Henry Hawkins Tremayne; and it being a question, whether this Tin might not come from some neighbouring Lode, it was discovered by the rod and sunk upon; but it proved a barren Vein for Metal in any quantity. A shaft was sunk at St. Germans, near the house of Francis Fox, to discover water; it drew the rod as Iron, and contained Mundick: another shaft was sunk between Penzance and Newlyn, according to the direction of the rod; the shaft lay deep beneath the surface, but a Lode containing much Mundick was discovered. In a close just by St. Austle, to satisfy the curiosity of some gentlemen, Mr. Cookworthy discovered by the rod the back of a Lode that had been wrought, but not turning to advantage the undertaking had been dropped, and the ground levelled. This Lode was traced just as the Miners informed the gentlemen it ran; and the Lode appearing by the rod at a certain place to be squeezed to nothing, the Miners declared this also to be true; for at this very spot where the Lode was thus squeezed, they lost it. Being required to discover a Lode that had been tried in the cliff under St. Austle Down, he found it in the country by the rod, and traced it to the cliff. It was a large Gossan-Lode; and as the attraction was found to stop, and after passing on a foot or two to begin again, he declared this was a cleft Lode, and had what the Miners call a Horse in it, which the Miners present who had wrought in it declared to be true.

Hence it is very obvious, how useful the rod may be for discovery of Lodes, in the hands of an adept in that science; but



but it is remarkable, that although it inclines to all Metals in the hands of unskilful persons, and to some more quick and lively than to others, yet it has been found to dip equally to a poor Lode, and to a rich one. I know that a grain of Metal attracts the Virgula, as strongly as a pound; nor is this any disadvantage in its use in Mining; for if it discovered only rich Mines, or the richer parts of a Mine, the great prizes in the Mining lottery would be soon drawn, and future adventurers would be discouraged from trying their fortune. But, indeed, we are so plentifully stored with Tin and Copper Lodes, that some accident every week discovers to us a fresh Vein; rich Mines having been several times discovered by children playing, and digging pits in imitation of shafts, whereby profits have arisen to their parents and others; and these puerile discoveries have in sundry places borne the name of Huel-Boys to this day.

Another way of discovering Lodes is by sinking little pits through the loose ground, down to the fast or solid country, from six to twelve feet deep, and driving from one to another across the direction of the Vein; so that they must necessarily meet with every Vein lying within the extent of these pits; for most of them come up as high as the superficies of the firm rock, and sometimes a small matter above it. This way of seeking, the Tinnerns call Costeening, from Cothas Stean; that is, fallen or dropt Tin.

Another and very ancient method of discovering Tin Lodes, is by what we call Shodeing; that is, tracing them home by loose Stones, fragments, or Shodes (from the Teutonick Shuten to pour forth) which have been separated, and carried off, perhaps, to a considerable distance from the Vein; and are found by chance in running waters, on the superficies of the ground, or a little under.

When the Tinnerns meet with a loose single stone of Tin Ore, either in a valley, or in plowing, or hedging, though at a hundred fathoms distance from the Vein it came from; those who are accustomed to this work, will not fail to find it out. They consider, that a metallick Stone must originally have appertained to some Vein, from which it was severed and cast at a distance by some violent means. The deluge, they suppose, moved most of the loose earthy coat of the globe; and, in many places, washed it off from the upper, towards the lower grounds, with such a force, that most of the backs of Lodes or Veins which protruded



protruded themselves above the fast, were hurried downwards with the common mass: whence the skill in this part of their business, lies much in directing their measures according to the situation of the surface.

Upon the top of most Tin Lodes, in the shelf or stratum under the loose mould and rubbish of the earth, is that mineralized substance, which is called the Broil or Bryle of the Lode. Though it is a part of the Lode, yet it is different in situation and appearance from all other parts of it; forasmuch as it is not confined between two walls, the stratum so near the surface being of a more lax tender texture, than in the solid rock a fathom or two under it. The Bryle, therefore, is very loose, and in some places scarcely metallick, for want of depth, and of those lateral chinks and cracks, which feed and nourish the Lode, at deeper levels, with Mineral principles educed from the strata of the earth.

Such is the Bryle of a Lode; consequently, when the waters of the deluge retired into their reservoir, great part of the Bryles of Lodes were carried off by the force of the waters to various distances, according to the gravity of Shode Stones, and the declination of the plane upon which they were dispersed. Tinnerns who describe this distribution of Shode, to make it more easily understood, compare it to a bucket of water discharged upon the declivity of a hill; near the bucket, it will take up but a small space; but as it descends, will spread wider, in the manner of a truncated cone.

Hence it is manifest to reason and experience, that the more distant Shodes are from the Bryle of the Lode, the more diverged they are, and fewer in number; and, by parity of reasoning, they are more in quantity near to the Bryle, and are collectively in less space. Nevertheless, in some certain situations, they are in greater quantities in valleys, than on the tops or sides of hills; but such are smaller, and more easily carried down by water, and formed into strata, which furnish our stream works. In level ground, they are found scarcely removed from the Bryle; but on a declivity, they are always found dispersed on the sides of the hill, at a greater or less distance, in proportion to the length or declivity thereof, and their own specific weight: consequently, the heaviest Stones are nearest to the Lode, and the lighter are protruded to a greater distance (even to five miles distance, as it is said in Philos. Transactions no. 69)

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which



which are also nearer to the foil, by means of their levity and size; while the more gross and weighty lie deeper interred as they are nearer the Lode. It is almost needless to observe, that as the texture, gravity, and black or brown colours of Tin Shodes, are different from all others; so they are thereby known and distinguished, as well as by the smoothness of them a great distance from the Lode, and the acuteness of their angles when near to it; which entirely depends upon the trituration they have undergone, rolling over rough surfaces, by the force of water, and the attrition of other bodies passing over them.

Henckell and Rosler say, "That Mundick Shode is very common; and that Wolfram, Granate, and Iron Corns, nay Quicksilver, are found in Shode and Stream." "All of which," Henckell further says, "were washed and tore away from their Veins, by the violence of the Noachian deluge."

Copper and Lead Shodes are very seldom met with; yet such there are. Their Bryles being chiefly composed of tender un-metallick Gossan, is not so well disposed for bearing that force and attrition, as the more stoney matter of Tin Lodes are; and the former generally is not mineralized into Copper Ore at the Bryle.

It is a mistake in those who deny the existence of any other Shode but Tin; so far from it, every hard stratum of the earth which is uppermost, will shew us numbers of their Shodes dispersed from them at a distance, and reclined upon strata of quite different natures, as hills and vallies are situated to help forward or retain those rocky fragments. I think our distinct loose Moorstone, or Granite rocks, upon the sides, and at the bottoms of our mountains, are the Shodes of their strata underneath; and many large Shodes of Irestone are to be seen, though in less plenty, dispersed upon Killas strata at a distance from their parent rock: all of which are incontestible witnesses of those violent conqassations and convulsions of our country, at the time of the flood.

It is much to be lamented, that the science of Shoding is greatly lost in the present age. Among all our Miners, we have not fifty, who scientifically or experimentally understand any thing of the matter; and those that are intelligent therein, are become old and feeble; whereby it is much to be feared, that



that this useful, and I think improveable science, is in danger of being practically lost.

Almost every Lode has a peculiar coloured earth or grewt (grit) about it; which is also sometimes found with the Shode, and that in greater quantity, the nearer the Shode lies to the Lode; beyond which that peculiar grewt is seldom found with the Shode. A valley may happen to lie at the feet of three several hills, and then they may find several deads grewt or earth moved by the waters of the deluge, but not contiguous to the Lode, with as many different Shodes in the middle of each. This is also termed the Run of the country; and here the knowledge of the cast of the country, or each hill in respect of its grewt, will be very necessary, for the surer tracing them one after the other as they lie in order.

Likewise, when the Miners find a good Stone of Ore or Shode in the side or bottom of a hill, they first of all observe the situation of the neighbouring ground, and consider whence the deluge could most probably roll that Stone down from the hill; and at the same time they form a supposition, on what point of the compass the Lode takes its course: for if the Shode be Tin, or Copper Ore, or promising for either, they conclude that the Lode runs nearly east and west; but if it is a Shode of Lead Ore, they have equal reason to conclude that the vein goes north and south. After finding the first Stone or Shode, they sink little pits as low as the fast rubble, which is the rubble or clay never moved since the flood, to find more such Stones; and if they meet with them, they go further up the hill in the same line, or a little obliquely perhaps, and sink more pits still, while they find Shode Stones in them; but they seldom sink those pits deeper than the rubble upon the shelf, except they are near the Lode. If the Shode is found in the vegetable soil, the Lode is not at hand; but if it lies deep, massy, and angular, it is a certain sign that the Lode is not far off; more especially if the Shodes are of a pyramidal or conical form, and the base or heaviest part of them lies pointing one way, it is both a sign that the Lode is not far off, and that it is to be found opposite to the base or heaviest part of the Stones.

The account which the learned Alvaro Alonzo Barba gives of discovering Silver Mines, by what I take to be Shoding; is very much like mine, and is as follows, p. 79. "The Veins of Metal are sometimes found by great Stones above ground; " and



“ and if the Veins be covered, they hunt them out after this  
 “ manner, viz. taking in their hands a sort of mattock (a pick)  
 “ which hath a steel point at one end to dig with, and a blunt  
 “ head at the other to break stones with, they go to the  
 “ hollows of the mountains, where the downfall of rain de-  
 “ scends, or to some other part of the skirts of the mountains,  
 “ and there observe what Stones they meet withal, and break  
 “ in pieces those that seem to have any Metal in them; whereof  
 “ they find many times both middling sort of Stones, and small  
 “ ones also of Metal. Then they consider the situation of that  
 “ place, and whence these Stones can tumble, which of  
 “ necessity must be from higher ground, and follow the tract  
 “ of these Stones up the hill, as long as they can find any of  
 “ them,” &c.

But to return—As they advance thus nearer the Lode with their pits, they find their Shode more plentiful and deeper in the ground; but if they chance to go further from the Lode, or pass the yonder side of it, there is a greater scarcity of the Shode, or perhaps none at all: in which case, they return to their last pit which produced Shode most plentifully, and work the intermediate ground, with more care and circumspection, by drifts from one pit to the next, until they cut the Lode. Sometimes they find two different Shodes in the same pit at different depths; then they are sure, that there is another Lode further on; and in training up to the second, they may meet with the Shode of a third. However, when they are just come to the Vein they set out for, they find an uncommon quantity of Shode Stones answering to the description before given, and then they say, that they have the Bryle of the Lode; upon which they dig down into the solid hard rock, which was never moved or loosened, until they open the Lode, and find its breadth by the walls in which it is enclosed.

Some Lodes, however, are so disposed, that they yield no Shode at all, nor are they to be discovered in a good depth; which may happen to be the case for several reasons. The situation of some places might have preserved their Veins from having their surfaces torn up and dispersed by the flood; or else, being so much torn and disturbed, their loose Bryle might have been totally carried off to a vast distance, towards which its poverty for Metal and consequential levity might contribute; in the place of which, a sediment or earthy part might have settled, and buried the Lodes so deep, that they are not discoverable



discoverable by shoding. Again, the backs of some Veins are depressed, and so deep under the firm solid rock which lies over them, that they do not make a rise or back immediately up to the loose stone or earth; that is to say, some Lodes make no back at all, and therefore produce no Shode, so that it is impossible to discover them, except by some favourable accident, of which I have known several instances.

These different dispositions of the strata I have taken notice of, sometimes deceive the Miners in shoding for Veins; for when they suppose that there is but one bed or layer of stones or earth over the firm ground, and there happens to be a double stratum of rock and rubble between, which is far from being uncommon, perhaps they dig no deeper than the first shelf; in other words, they dig no deeper than till they think they are come down almost to the fast or firm ground, where they expect to find either the Shode or the Bryle of the Lode; but as they are covered by the other shelf or stratum, which the Miners are not apprized of, they have their labour for their pains, in seeking in such uncertain ground, which perhaps contains a double or treble shelf.

The Miners are of opinion, that the waters by their great emotion, did not only remove, and confuse the surface of the earth, but also broke the looser parts of Veins from off their superficies or backs; and thereby disordered and removed the face of the earth as deep as the fast and firm rock or stratum, as I have said before: and indeed our apprehension of the matter very much favours this supposition: whence, undoubtedly, those Shodes or fragments of Veins are the vestiges or remains of the deluge. Hence it is, that part of the Shode has been rolled down the declivities of hills from the Mines; moreover, that Shode which is found a great way distant from the Mines, is much more worn and smoother than that which is nearer to it, as it happens to stones on the sea shore, or on the sides of rapid rivers, which are fretted and worn smooth by the agitation of the waters, and the friction of other bodies. If any person will but consider the sea cliffs, he may observe, in several places, that the upper coat or covering of the earth, has been greatly moved and agitated; and that the loose stones did preponderate and subside on the firm rocks, pursuant to their specifick gravities; next those, the rubble resided, and over all the pure light earth rested. Yet this order is not absolutely perfect and without exception; for loose stones are often found in the light  

L 1
earth,



earth, and on its superficies; which by the impetuosity of the waters, and situation of particular places, were molested in subsiding. For we are not to suppose our globe to resemble a trough, or the like excavated figure, wherein the variously mixed earths are to be regularly disposed, as in the operation of buddling or washing of Ores; but to be of a spherical arched figure, where the waters, as on a hanging bottom, powerfully rend, and pull it asunder: and this force of the waters we may suppose to be greatest at the beginning and end of the deluge.

So likewise, in some places, the loose earth and stone, which cover the firm rocks, lie in strata; for immediately on the rock, there may be, for instance, a layer of sand or clay, and over that a bed of large stones, and so alternately stratum super stratum, for some depth. Now these variations might very well happen on the decrease of the deluge: for when the flood was high and more at rest, the slimy light earth was deposited downwards; but when the waters came lower, and bent their course to the beach, then it came to pass that there was a strong current from off the land to the sea, which rolled down the loose stones upon the mud or sediment that fell and settled beforehand; so this current might have been interrupted again by the situation of the place and interposition of high ground, till the water had let fall another sediment, and afterwards found or perhaps broke another passage for itself through the land. This might have happened several times in the deluge, till at last the remaining water partly evaporated and partly sunk into the ground, leaving the deepest earth or sediment where it continued longest; as it happens frequently in floods or overflowings of water, where we may observe the situation of high and low grounds do not a little contribute to the same kind of effects that are here spoken of.

Another way of discovering Lodes, is by working drifts across the country as we call it, that is from north and south, and vice versa. I tried the experiment in an adventure under my management, where I drove all open at grass about two feet in the shelf, very much like a level to convey water upon a mill wheel; by so doing I was sure of cutting all Lodes in my way, and did accordingly discover five courses, one of which has produced above one hundred and eighty tons of Copper Ore, but the others were never wrought upon. This method of discovering Lodes, is equally cheap and certain; for a hundred fathoms



fathoms in a shallow surface may be driven at fifty shillings expence.

In feasible (tender standing) ground, a very effectual, proving, and consequential way is, by driving an adit from the lowest ground, either north or south; whereby there is a certainty to cut all Lodes at twenty, thirty, or forty fathoms deep, if the level admits thereof. Such depths are proving the Lodes discovered by them, and the adit will serve to drain all parts of the strata above it; and likewise be a discharge for all water drawn from the Mine into it; so that it is effectual for discovery, proving for trial, and consequential to the future working of a Mine. But in Granite, Elvan, and Irestone strata, this cannot be complied with, neither is it adviseable but under certain circumstances, where the ground is to be wrought for eighteen shillings  $\text{per}$  fathom, unless a Cross-Gossan lies ready at hand, when the method in use is to drive partly on one side of the Gossan, breaking down the adjunct wall of it, whereby they drive the adit cheaply, expeditiously, and effectually for discovery. In driving adits or levels across, north or south, to unwater Mines already found, there are many fresh Veins discovered, which frequently prove better than those they were driving to. Witness the Pool adit in Illugan, where the late John Pendarvis Basset, Esq; cleared above one hundred and thirty thousand pounds.

## C H A P. II.

### Of Streamings, and Smelting of Stream Tin in the Blowing-House, &c.

**W**E cannot help repeating in this place, that the deluge is an event which has produced the most remarkable alterations in the earth, and to which many effects observable at this day are to be ascribed. The history of the deluge gives great light towards the knowledge of nature, and the present state of the earth seems to verify that event: by the violence of the deluge the Mineral kingdom was thrown into confusion, parts before conjoined were separated, Ores and Veins were dislodged, and new beds and positions given them. The several strata in which Minerals are at present found, afford convincing instances, as well of the truth of this event, as of the confusion wrought by it, especially



especially in parts where Clay, Sand, Rubble, Stone, and the like, lie in beds and layers on each other. But I suppose there are no particular instances under the sun, that can afford us so clear an idea of the flood and its effects, as the Stream works in St. Austle, Roach, St. Dennis, St. Stephen's, Luxillian, and Lanlivery.

It happens that what I have already said in my account of shode and shoding, together with my section on the article Tin in chapter the 3d, book the 1st, leaves little more for me to say on the subject of Stream Tin. I must, therefore, wave the description of it here, and refer the reader back to those places. Of course nothing else remains than to describe the manner of Streaming, upon which I shall be concise because it is a part of my subject that is very simple and less important than deep Mining to the community in general; but as it occurs, in the course of my writing, more naturally in conjunction with or immediately after the method of shoding, I beg leave to introduce it in this place.

When a Streaming Tinner observes a place favourable in situation, he takes a lease, commonly called a Set, of the land owner or lord of the fee, for such a spot of ground, and agrees to pay him a certain part clear of all expence in Black Tin; that is, Tin made clean from all waste, and ready for smelting. The consideration is generally one sixth, seventh, eighth, or ninth, as can be settled between them; or, instead thereof, he contracts to employ so many men and boys annually in his Stream work, and to pay the land owner, for liberty, from twenty to thirty shillings a year for each man, and so in proportion for every boy; that is, for twelve shillings monthly wages, he articles to pay the lord half as much as for a man.

He then sinks a hatch (shaft) three, five, or seven fathoms deep, to the rocky shelf or clay; on both of which in the same valley, the Tin is frequently stratified, without any difference in its being more abundant in one than the other. It is found in different places, in different depths; and sometimes stratified between what is called a first, second, or third shelf, which is reconcileable upon the principles laid down in my chapter upon shoding, &c. The stratum of Stream Tin may be from one to ten feet thickness or more; in breadth, from one fathom to almost the width of the valley; and in size, from a walnut to the finest sand, the latter making the principal part of the Stream,



Stream, which is intermixed with stones, gravel, and clay, as it was torn from the adjacent hills.

When he sinks down to the Tin stratum, he takes a shovel full of it, and washes off all the waste; and from the Tin which is left behind upon the shovel, he judges whether that ground is worth the working or not. If it is proving work, he then goes down to the lowest or deepest part of the valley, and digs an open trench, like the tail or low slovan of an adit, which he calls a Level, taking the utmost care to lose no levels in bringing it home to the Stream. This level serves to drain and carry off all water and waste from the workings, in proportion as he hath a weak or powerful current of water to run through it. Some places are very poor and not worth the expence for working; others again are very rich and thence called Beuheyle or Living Stream, as is most commonly the case if it is of a Grouan nature, which being more lax and sandy, is more easily separated from its native place or Lode, and therefore more abundant and rich in quality according to the known excellence of Grouan Tin.

In the latter case, the Streamer carries off what he calls the Overburden, viz. the loose earth, rubble, or stone, which covers the Stream, so far and so large, as he can manage with conveniency to his employment. If in the progress of his working he is hindered, he teems (or lades) it out, with a scoop, or discharges it by a hand pump: but if those simple methods are insufficient, he erects a rag and chain pump so called; or if a rivulet of water is to be rented cheaply at grasse, he erects a water wheel with ballance bobs, and thereby keeps his workings clear from superfluous water, by discharging it into his level: mean while his men are digging up the Stream Tin, and washing it at the same time, by casting every shovel full of it, as it rises, into a Tye, which is an inclined plane of boards for the water to run off, about four feet wide, four high, and nine feet long, in which, with shovels, they turn it over and over again under a cascade of water that washes through it, and separates the waste from the Tin, till it becomes one half Tin.

Though there is little dexterity in this manœuvre, yet care is requisite to throw off the Stent or rubble from the tye to itself, whilst another picks out the Stones of Tin from the Garde or smaller pryany part of it. During this operation, the best of



the Tin, by its superior gravity, collects in the head of the tye directly under the cascade ; and by degrees becomes more full of waste, as it descends from that place to the end or tail of the tye, where it is not worth the saving. If there is a copious stream of water near at hand, they cast this refuse into it, by which it is carried so far as to make its exit into the sea, for which practice they certainly deserve our severest censure ; at least, if the choaking of harbours and rivers, and the destruction of thousands of acres of improvable meadow land, are not more than an equivalent for the casual and temporary profits arising from Stream Tin.

I need not mention, that in the usual method of Streaming for Tin, the soil is either thrown into the bed of the rivers, or buried under the gravel and stones that form the interior strata ; by which such land is rendered irreclaimable. That the Bounder, or working Tinner, should thus wantonly destroy what he had no interest in preserving, seems by no means extraordinary ; but can we say the same for the lord of the soil ?

Surely, it did not require any great degree of penetration, to have comprehended Streaming and Draining under one idea, and thus have made the improvement of the surface go hand in hand with the extraction of the Tin. The additional trouble of removing back the soil in heaps, and levelling the Stream ground to receive it, is so little that I know, by several instances, the Tinner will have but little reluctance in acceding to ; which the reader will readily apprehend when I assure him, the overburden upon the Stream is digged and rolled off at some distance, for only eightpence a cubick fathom ; but at all events it is the interest of the proprietor to have it done, either by the Streamer or some other person. This method has been pursued in some parts of the county of Cornwall, and has been attended with the success so laudable an undertaking merits ; as thereby those springs which lie too deep for the ordinary modes of draining, have been most effectually cured. I hope I shall not be accused of exaggeration when I assert, that the rental of this county, by following this obvious method of procedure, might have been increased in a proportion almost equal to the present value of the Stream Tin ; and this too without lessening its produce, or injuring in the smallest degree the ducal revenue.

That this practice was not adopted by our ancestors, was owing to the small comparative value of land in those days, considering



considering either the state of population or the uncertain and precarious tenures under their feudal lords. But when Britons have long since wrested, from their petty monarchs, the property of the soil, together with the invaluable privilege of transmitting their improvements from father to son, that a custom so injurious to the community, as well as to the individual, should still continue;

— “pudet hæc opprobria nobis  
“Et dici potuisse, et non potuisse refelli.”

After the Tin is thus partly dressed in the raising of it, they carry it to grafs; and when a competent quantity is collected, they proceed to dress it for blowing. There are several ways of dressing this kind of Tin; but the general method is, to make what they call a Gounce, which is nothing more than a small tie before described, and what we call in the Mining parts a Strêke, in which the smaller tin is washed over again as was done before in the tye, but with a less current of water, and a larger degree of care and caution, lest the Tin be carried off with it. The richer part of the Tin, as before mentioned, lies nearest the head of the gounce, which is carefully taken up, divided, or kept separate, according to its goodness, and put into large vats or kieves; while the waste that lies in the hinder part of the gounce, is dressed over again, till all the Tin is taken out, and the remaining waste becomes absolute refuse. The Tin is then sifted through wood or wire sieves, whereby the greater particles are divided from the smaller; by this method, likewise, the waste from its levity lies uppermost in the sieve, which is carefully skimmed off, and laid aside to work over again. The smallest Tin which passes through the wire sieve, is put into another finely weaved horse-hair sieve, called a Dilluer, by which and the skill of the workman, it is made merchantable. Some of the nodules or lumps of Tin are blowed or smelted as they come out of the tie; but those which are mixed with waste, are put with the refuse of the garde and poor Tin, which were in the tails of the tye and gounce, and being sent to the stamping mill, are triturated and pulverised, so that all waste may be cleared from the Tin by sundry ablutions, the same as are performed in the dressing of Mine-Tin.

Besides these Stream works, we have another sort of them occasioned by the refuse and leavings from the stamping mills, &c. which are carried by the rivers down to the lower grounds; and

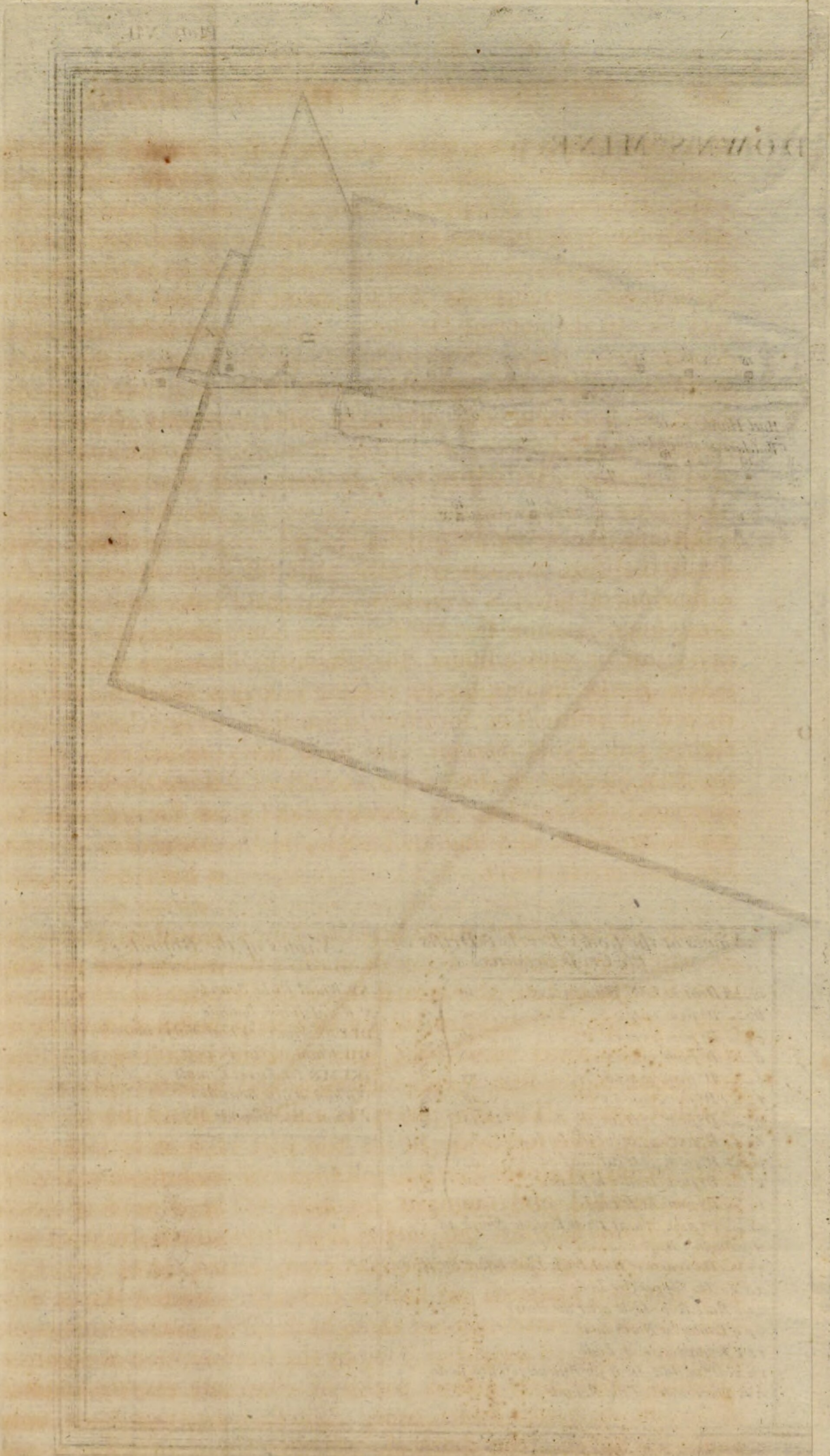


and after some years lying and collecting there, yield some money to the laborious dressers, whom they distinguish by the name Lappiors, I suppose from the Cornish word Lappior, which signifying a Dancer, is applied to them, from the boys and girls employed in this work, and moving up and down in the buddles, to separate the Tin from the refuse, with naked feet like to the ancient Dancers. I have been told, that about seventy years back, the low lands and sands under Perran Arrowthall, which are covered almost every tide with the sea, have, on its going off, employed some hundreds of poor men, women, and children, incapable of earning their bread by any other means. To return :

Stream Tin being prepared and made ready for blowing with a charcoal fire, is carried to the blast furnace, which is called a Blowing-House ; where, formerly, the Tinner might have his Tin blown, paying the owner of the house twenty shillings for every tide or twelve hours, for which the blower was obliged to deliver to the Tinner, at the ensuing coinage, one hundred gross weight of white Tin for every three feet, or one hundred and eighty pounds of Stream Tin so blown ; which is equal to fourteen pounds of Metal for twenty of Mineral, clear of all expence. Now, that the blowing-houses are farmed, the Tin is usually blown and sold by sample, as the Mine-Tin is at the reverberatory furnaces.

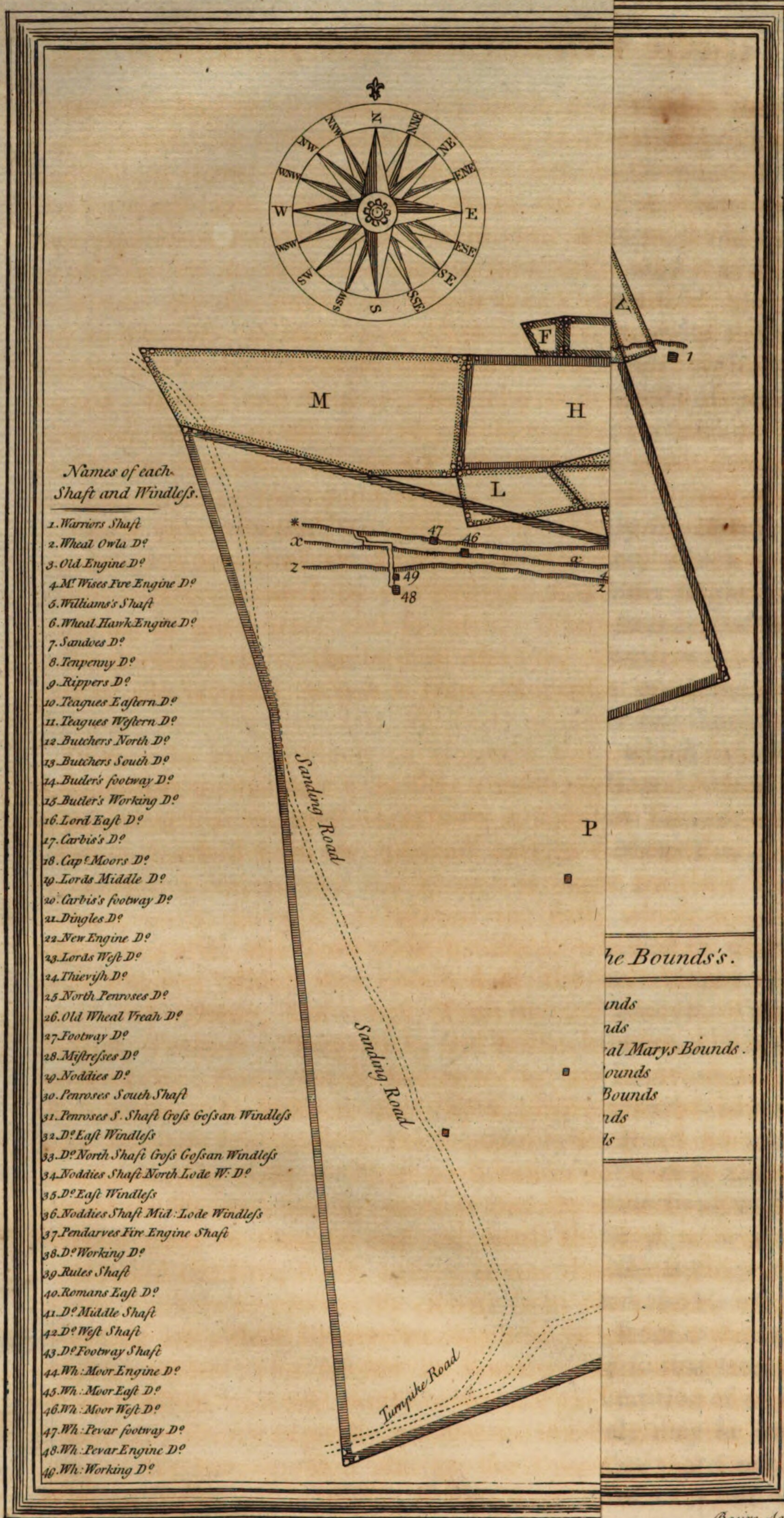
The furnace itself for blowing the Tin, is called the Castle, on account of its strength, being of massive stones cramped together with Iron to endure the united force of fire and air. This fire is made with charcoal excited by two large bellows, which are worked by a water wheel, the same as at the Iron forges. They are about eight feet long, and two and a half wide at the broadest part. The fire place, or castle, is about six feet perpendicular, two feet wide in the top part each way, and about fourteen inches in the bottom, all made of moorstone and clay, well cemented and cramped together. The pipe or nose of each bellows is fixed ten inches high from the bottom of the castle, in a large piece of wrought Iron, called the Hearth-Eye. The Tin and charcoal are laid in the castle, stratum super stratum, in such quantities as are thought proper ; so that from eight to twelve hundred weight of Tin, by the consumption of eighteen to twenty-four sixty gallon packs of charcoal, may be smelted in a tide or twelve hours time. Those bellows are not only useful for igniting the charcoal, but they throw in a steady and  
powerful





17th Paper  
in the hands of the collector





To the Rev<sup>d</sup> Francis C.  
Engraver



powerful air into the castle; which, at the same time that it smelts the Tin, forces it out also through a hole at the bottom of the castle, about four inches high, and one inch and a half wide, into a moorstone trough six feet and a half high, and one foot wide, called the Float; whence it is laded into lesser troughs or moulds, each of which contains about three hundred of Metal, called Slabs, Blocks, or Pieces of Tin, in which size and form it is sold in every market in Europe; and on account of its superior quality is known by the name of Grain Tin, which brought a price formerly of seven shillings, that is further advanced, the last two or three years, to ten or twelve shillings & hundred more than Mine Tin is sold for, because it is smelted from a pure Mineral by a charcoal fire; whereas Mine Tin is usually corrupted with some portion of Mundick, and other Minerals, and is always smelted with a bituminous fire, which communicates a harsh sulphureous injurious quality to the Metal.

## C H A P. III.

Of Bounds and the Manner of taking a Set or Grant for Mining; of Sinking of Shafts, Driving of Adits, Digging and Raising of Ores, and Working the Mines, &c.

**P**REVIOUS to the working of a Tin Mine, a Grant or liberty must first be procured from the lord of the soil, if it is in Several and not bounded; but if the ground is in Wastrel and bounded, no liberty from the lord is necessary, but from the Bounder only. These Bounds are limited portions or pieces of land, enjoyed by the owners of them in respect of Tin only; and by virtue of an ancient prescription or liberty for encouragement to the Tinnors. They are limited by holes cut in the turf, and the soil turned back upon the turf which is cut, in form of a mole hill, and directly facing another of the like kind; these are called Corners of the Bounds, containing sometimes an acre, sometimes more, and often less. By drawing straight lines from the Corners, the extent of these Bounds is determined; in like manner as in geometry, by drawing straight lines from three or four points, the extent of a triangular or quadrangular superficies is known.

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By observing the legal forms, if the land is neither bounded nor inclosed, but a Wastrel or common, then may any one mark out Bounds there, and search for Tin; but, in compliance with the Stannary laws, whoever intends to cut a Tin Bounds must first give three months notice of his intention in the Stannary court, and to the lord, for him to shew cause why it shall not be done. By this procedure, the lord is advertised of a certain loss to himself, whence he presents an instrument, praying for liberty and enrolment of such Bounds within that Stannary, to his own behoof and benefit; whereby it is pretty clear, that new Bounds are at this day very seldom cut, to which the late gentlemen Stannators no doubt had an eye; because it is no uncommon thing for Bounders who have no title to any part of an estate above-ground, to grant sets for Tin without the least exception in favour of the Lord whose estate on the green side is oftentimes damaged by the destruction of the soil and the levelling of his fences, and so forth. The damage, however, is sometimes little to the lord of the soil, who has a fifteenth part of all that rises, which is some compensation for his loss.

It may be very difficult to ascertain the precise date when Bounds first commenced; but by consulting some manuscripts which were lent me by Francis Gregor, Esq; of Trewarthenick, whose father had been an able and upright vice-warden of our Stannaries, I observe that the Tinnors wrought for their Tin by custom, until the 33d of Edward the first, which was sixty-four years after the Jews were banished, when they procured their charter, which was obtained at the solicitation of the lords of Trethewy, Boswithgy, Treverbyn, Prideaux, Trenans, Austell, Tremedry, Tregarriek, and Milliack, who obliged their lands to pay assent, and do service to the law courts erected by the charter. I elsewhere find by some manuscript papers of John Cooke, Esq; one of the Stannators for Blackmore, 11th of Charles the first, "That by occasion of certain disputes, "and the Tynners having greates profits by their Tynn wrought "from time to time by custom, untill the 33d year of king "Edward the first, A. D. 1305; it was then thought good for "the Tynners to procure by charter from the prince, freely to "grante unto them libertye to digg and search for Tynn in any "place where Tynn mighte be found; and a court to deter- "mine all matters and causes between Tynners." Accordingly I find this liberty expressly granted in the said charter, which says, "We have granted also to the Tynners, that they may "dигge Tynn and turf for the melting of the Tynn, every "where



“ where in our lands, moores, and waistes ; and of all other  
 “ persons whatsoever, in the county aforesaid.” Mr. Beare also,  
 in his Bayliff of Blackmore a manuscript of ancient note, in his  
 discourse upon what the Tynners did before the charter was  
 granted, says, “ That they always used to worke, and searcho  
 “ for Tynn in wasterall grounds, and also in the prince’s  
 “ Severall, where any Tynne mighte be gotten ; having likewise  
 “ libertye to digge, mine, searcho, make Shafts, pitch Bounds ;  
 “ and for Tynne to worke in places of their most advantages :  
 “ excepting only sanctuary grounde, church yards, mills, back  
 “ houses, and gardens ; paying only to the prince or lord of  
 “ the soyle, the fifteenth part to and for the toll of their  
 “ Tynn.”

The sum of all the intelligence I can procure, inclines me to  
 judge, that all Tin was at first the possessionary right of him  
 who had the government of the county, and from whom the  
 liberty was granted, (or from the king) immediately to the  
 searcho. (Plow. Com. Pearce’s Stannary Laws ; Sir John  
 Doddridge.)

Without determining when a custom of that kind commenced,  
 it is very natural to suppose, that those grants were limited and  
 circumscribed within certain Bounds, beyond which, as at this  
 day, the searchoers dared not to pass. The acquisition of this  
 valuable property, could not admit of its being in common ;  
 but under certain limits, and prescriptive forms, it must have  
 been kept separate and divided between the sundry proprietors ;  
 in order that each person might know and preserve his own  
 property. Whatever modes of partition the moderns might  
 have thought of, there yet seems none more simple and decisive  
 than those here described, which have existed from their first  
 adoption to the present hour. Notwithstanding this, by the  
 negligence of some owners of Bounds, the knavery of others, and  
 the glorious uncertainty and chicane of the law, no Stannary  
 affairs are so fertile of wrangles and disputes as those which  
 relate to Tin Bounds.

The first institution of those customary tenures, for the en-  
 couragement of searchoing for Tin, was laudable and wise ; but  
 the late increase of Tin and discovery of Lodes, together with  
 the present improvements in Mining, very much diminish the  
 necessity of this kind of encouragement. On the contrary, from  
 very



very good reasons I can assert, it would be well for this country in general, if Tin Bounds were totally obliterated.

To preserve the right of a Bounds, it ought to be renewed once every year, which is performed in different Bounds on different saints days, as St. John, St. Peter, St. Paul, &c. by the servant called the Tollur, the Renewer, or the Bounder, who cuts out a turf from each hole or corner, which he places upon the top of the little bank formed by the turfs already laid there, and declares the renewal to be on the behalf of such person or persons, the Bounds owners; from whence he generally goes to some house of entertainment, and takes a dinner, and other refreshment, in order to celebrate and commemorate that annual renewing day.

In Several, no man can search for Tin without leave first obtained from the lord of the soil, who, when a Mine is found, may work it himself, or associate partners, or set it out at a farm certain, or leave it unwrought at his pleasure. In Wastrel, it is lawful for the bounder, or any other person having liberty from him, to dig and search for Tin, provided that he acknowledges the lord's right, by sharing out unto him a fifteenth part of the whole. Then it is lawful for the Bounder to take out one-twelfth, or in some places by peculiar custom one-tenth of the remainder. Tanners may drive an Adit through others Bounds without their liberty, only as a passage for their water; but if they break Tin or discover a Lode in their drift or sinking of Shafts, they have no benefit of the said Tin or Lode, but shall leave it wholly to the owners of the Bounds within which it is.

The usual grant for Tin where it is not bounded, is the same as for Copper; and the acknowledgment, Dish, or Dues paid to the lord, is commonly one-sixth, seventh, eighth, ninth, even to one-twelfth, or less under some peculiar circumstances; only that the dues for Copper are payable in money, and for Tin in the Stone or Mineral Ore, and sometimes in white Tin or Metal. This grant by lease, is called a Set for Tin or Copper, and runs for one and twenty years certain. But a Set of a Bounds for Tin, though verbal, is perpetual, and never ends while it is wrought according to the laws and customs of the Stannaries; that is, if the Tinner has been in quiet possession for the space of one year and a day, he may still keep his holding at five shillings expence annually, laid out upon the premises. This

is



is a very injudicious indulgence, and it is an injurious licence for the benefit of the Bounds owners. I can answer for the truth of this, and so can almost every other Bounds owner in the county; it being no rare thing for a Tinner to keep possession of a Bounds Set, like the dog in the manger.

I do not suppose the present methods for working of Tin Mines, by deep Shafts, and by Driving and Stopeing under the firm ground, has been practised more than three hundred years past. Prior to those means for raising of Tin, they wrought a Vein from the bryle to the depth of eight or ten fathoms, all open to grafs, very much like the fosse of an intrenchment. This was performed by meer dint of labour, when men worked for one-third of the wages they now have. By that method they had no use for foreign timber, neither were they acquainted with the use of hemp and gunpowder.

This fosse they call a Coffin, which they laid open several fathoms in length east and west, and raised the Tin-stuff on Shammels, plots, or stages, six feet high from each other, till it came to grafs. Those Shammels, in my apprehension, might have been of three kinds, yet all answering the same end. First, they sunk a pit one fathom in depth and two or three fathoms in length, to the east and to the west, of the middle part of the Lode discovered; then they squared out another such piece of the Lode for one or two fathoms in length as before, at the same time others were still sinking the first or deepest ground sunk, in like manner; they next went on and opened another piece of ground each way from the top as before, while others again were still sinking in the last and in the deepest part likewise: in this manner they proceeded step after step; from which notion arises the modern method of Stopeing the bottoms under-ground. Thus they continued sinking from Cast to Cast, that is, as high as a man can conveniently throw up the Tin-stuff with a shovel, till they found the Lode became either too deep for hand work, too small in size, very poor in quality, or too far inclined from its underlie for their perpendicular workings. Secondly, if the Lode was bunchy, or richer in one part than another, they only laid open and sunk upon it, perhaps in small pitches not more in length than one of the Stopes or Shammels before described. The shortness of such a piece of Lode would not admit of their sinking Stope after Stope; it was then natural and easy for them, to square out a Shammel on one side or wall of their Lode, and so to make a landing place

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for



for their Tin-stuff cast after cast. Thirdly, if the Lode was wide, and the walls of it, and the adjoining country, very hard solid ground, it was in such case more easy for them to make Shammels or stages, with such timber, &c. as was cheapest and nearest at hand.

This, with Streaming, I take to be the plain simple state of Mining in general, three centuries ago; and from hence is derived the custom of Shammeling both above and under-ground at this time; for in the clearing of Attle, (Deads) or filling the Kibble with Ore, the Miners prefer a Shammel, which is a stage of boards, for the more light and easy use of their shovels.

But as this manner of working was irreconcilable with the discovery and raising any Tin-stuff below a certain very shallow depth, it became necessary to contrive some other way to follow downwards the inviting rich stones of Tin some Lodes produced. The method of Shammeling, even in those moderate times, has been expensive, where a very small Lode of Tin occurred in a hard country. To remove a dense hard stratum of rocky overburden, must be very fatiguing and perplexing; therefore they found it most adviseable to sink Shafts down upon the Lode, to cut it at some depth, and then to Drive and Stope east and west upon the course of the Lode: in time, no doubt, such improvements presented, as rendered that the cheapest and most established custom of Mining.

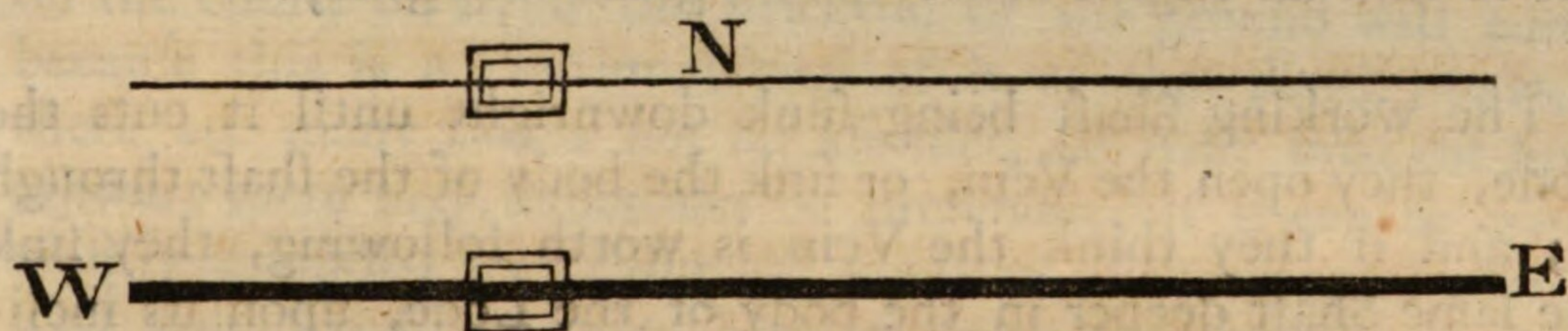
The speculative reader may be apt to imagine, that we can trace, and distinguish, the different advancements which have been made in Mining, by the depth and proportion of old Shafts, &c. But it is not so; for Shafts, and other workings of the Mines, depend upon the same, and yet different contingencies, in one and the same Mine. It is very likely, that a hundred years since, a Shaft would not be sunk in a certain place but fifteen fathoms deep, from the quantity of water; where it now may be done beyond fifty fathoms, without a drop. The reason of this is not because the skill of the present occupiers is greater than that of the former; but because the adjoining strata or country is Bled, as we call it, by Adits, and fundry other drifts and levels, driven through them posterior to that time.

Having shewn how Sets for Tin and Copper are granted, and how Tin was anciently sought for, at a time, indeed, when  
Copper



Copper was as well known to be in Terra incognita, as in Cornwall, we ought to proceed to the discovery of the Lode: but as this has been described elsewhere, we shall now set forth the first arrangements for working a Mine; in order to which, the principal thing to be thought of is a Shaft to cut the Lode, at twenty or thirty fathoms deep, if it is possible to be done. Here it is necessary to form some judgment of the inclination or underlye of the Lode, before we attempt to sink a Shaft: for instance, if the Lode underlies to the north about three feet in a fathom, and a Shaft is designed to come down upon the Lode in twenty fathoms sinking, the Miner must go off north from the back of the Lode full ten fathoms, and there pitch his Shaft; by which means he is certain to cut the Lode in the Shaft about twenty fathoms deep; because for every fathom the Lode descends in a perpendicular line, it is also gone three feet to the north of the perpendicular.

But to render this the more conspicuous, let the line E W represent the back or surface of a Lode pointing east and west, and whose underlie is north: by sinking a Shaft upon this back, it will soon be deserted by the Lode, which is gone further north three feet for every fathom that is sunk upon that line; so that when the Lode is twenty fathoms deep, it must be gone north to the imaginary line N, where another Shaft must be sunk to cut the Lode at that depth.



A proper working Shaft, upon which a Whym may be erected if necessary, should be six feet long and four feet wide, or more where large water barrels may be wanted; and the harder the ground is, the longer and wider the Shaft ought to be, that the men may have the more liberty to work and break it, the area of a large shaft being more easy to rip up where the ground is hardest, than of a small one where it is more confined together, and breaks in shreds of stone, &c.

In



In many parts of the Mining district, the north or the south channel appears to full view; and it is a maxim among the Miners, when they erect their windlafs upon a Shaft, to place it true to the horizon; in order to which they make an observation in a line to the farthest distance they can see, which is always the same height as the eye of the observer, either upon the highest hill, or with the edge of the water.

A Shaft that is designed for a water engine, may serve, if it is of the size of the largest working Shaft; but a fire engine Shaft ought to be, at least, nine feet square, or ten feet by eight, or in fact to contain three Shafts in one, which must be partitioned into three compartments, all the way down from grafs to the deepest bottom of the Mine. One half is divided for the pumps and engine work; three feet in length of the other is proportioned for a foot way, to go down and rectify the pumps when amiss; and the remainder is divided also by a partition of boards, for a whym Shaft to draw the Deads and Ore from the Sump of the Mine. If the ground is hard and very wet, or the water very quick upon the men in sinking, there ought to be eight men employed to sink a working Shaft; that is, two men in a corps of every six hours; and in a fire engine Shaft, there should be sixteen employed in the same manner: but if the ground is tender, and there is no hindrance by water, six men in the first, divided into three corps every eight hours, are reckoned sufficient; yet I have known four and twenty men put to sink an engine Shaft upon a great emergency.

The working Shaft being sunk downright until it cuts the Lode, they open the Vein, or sink the body of the shaft through it; and if they think the Vein is worth following, they sink the same Shaft deeper in the body of the Lode, upon its inclination or underlie; whence the Shaft becomes, and bears the name of, an Underlier: at the same time they turn house, as they call it, from the bottom of their perpendicular, or from the top or beginning of the underlie. So that when the Lode is well impregnated, they turn house by driving or working horizontally on the course of the Vein, either to the east or to the west, or both, as they find it most likely to answer their expectations, in order to make a fuller trial and discovery. Where the Lode answers well in thus driving upon it, they continue to do so, till they are prevented by want of air; or till the end of their workings is too far from the Shaft, and the expence of rolling back the stuff to the Shaft is great and incommodious;



incommodious ; then it is proper to put down another Shaft as before described, or more to the north, because it will be more convenient, the longer it continues downright. Mean while, they are mindful to sink their first Shaft in order that they may work away the Lode from thence in Stopes, and have a little Sump or pit in that place as a bason for receiving the water of the Lode, whence they discharge it to grafs by the easiest method they can devise : for most Lodes have streams of water running through them ; and when they are found dry, it seems to be owing to the waters having been forced to change their course, either because the Lode has stopped up the old passages, or because some new or more easy ones are made, whereby the Lode and strata adjacent to it are bled as we term it. However, they are often hindered from going down deep enough to find any great quantity of Ore, by the burden of water that most Veins abound with ; therefore, if the Mine is not encouraging, they give over any further pursuit ; but if it seems likely to prove well, and the Lode lies in an ascending ground, they quit the Vein for the present, and go down to the most convenient place in the valley, and from thence they bring a Trench, Drain, or Conduit, which they call an Adit, Tye, or Level ; and so they work and drive this passage through the hill in a right line to the Lode, with very little loss of the level they began from.

Where the Adit is intended only for the sake of unwatering one particular Vein, it is frequently adviseable to bring it home on the course of it, if the situation of the ground will admit, because this is a continual trial of it at that depth : yet, if there are many Lodes not far asunder, an Adit brought home athwart them may sometimes be preferable, if it can be conveniently complied with ; for the situation of the ground must be well considered, to judge how to drive home the most short, deep, speedy, and cheap Adit, with the most probable success.

If the hill takes its course east and west a considerable length, and the discovery of the Vein is very far from a valley at either end of the hill, there may be no choice in the matter ; for the shortest and cheapest Adit will of course be driven from the north or south, unless moorstone or irestone strata intervene. It then behoves the adventurers to seek for a Cross-Gossan, where it lies convenient in distance from the discovery, to bring home the Adit in ; and provided the Gossan does not exceed three feet in width, it is reckoned very favourable, because the



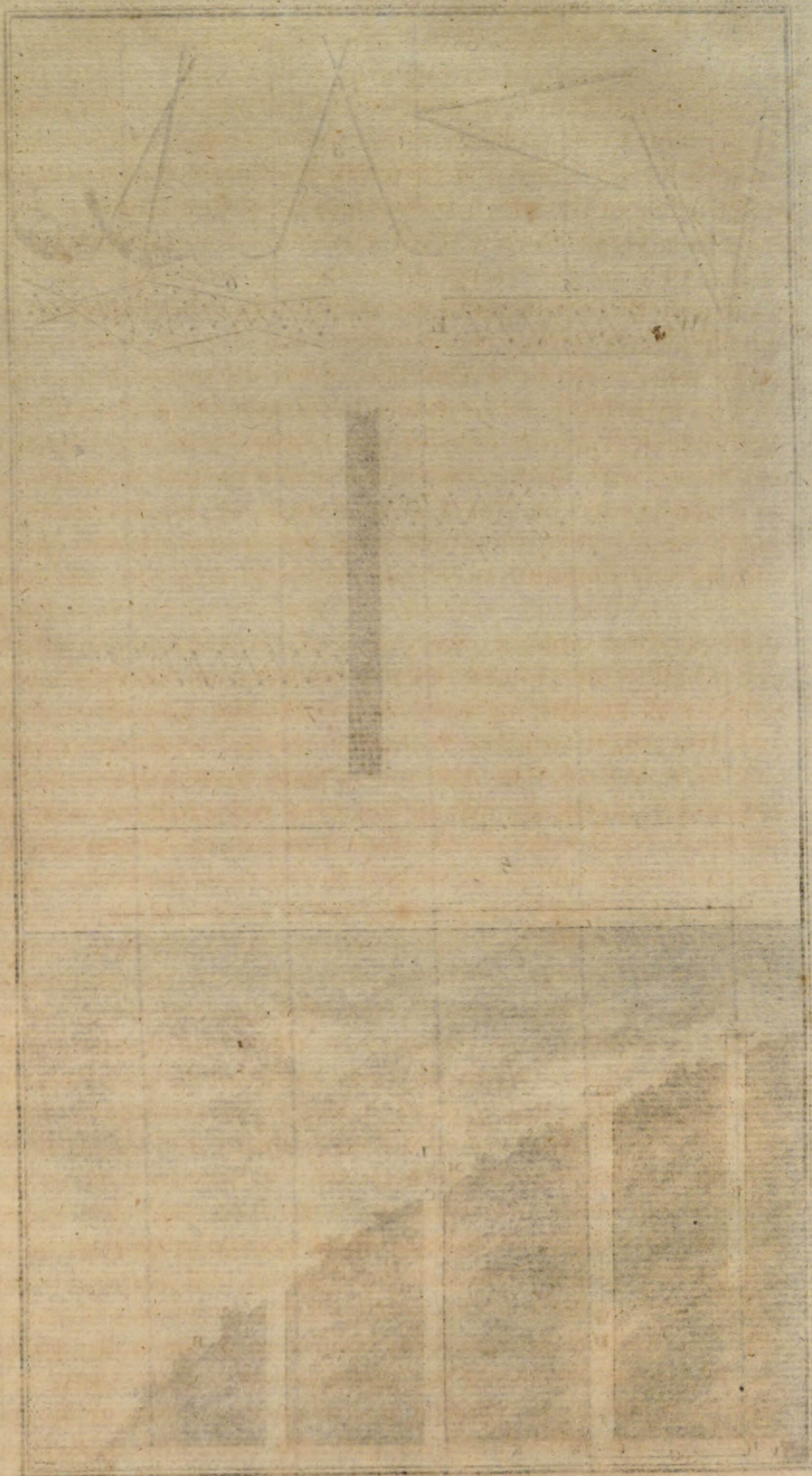
Adit may be wrought through the body of it, without the use of timber and boards to support and keep it up. On the contrary, most Cross-Gossans are too wide to break down the whole breadth for an Adit; and therefore they drive on the eastern or western side of it, which ever is most to their liking, and at the same time break down a small thickness of its contiguous wall, so that they are sure to cut all Veins, and branches of metallick Veins, in their passage to the Mine; by which means, as in driving levels across the country out of those cross-courses, many more valuable Lodes have been discovered, than those they were driving to unwater. Nevertheless that side of the Adit which is in the body of the Gossan, must be braced up, and bound with boards, as must likewise its back or top, otherwise the hinder part of the level may fall in and occasion a choak in it. Yet there are some few Gossans that will stand without any support.

These Adits are commonly six feet high and about two feet and a half wide, so that there may be room enough both in height and breadth to work in them; and also room to roll back the broken deads in a wheel-barrow: but if the ground or rock be very hard, the Adit ought to be more spacious or large each way, to give the greater liberty or room to work and break the stone. An Adit requires four men to work it constantly by day and night, and a boy or two to roll back the broken work, if they break it very fast.

The necessity for Shafts in driving an Adit, occurs very frequently to supply the workmen with air, and for the convenience of winding up the deads. Where the country is very hard, the Shafts should be forty fathoms distant from each other; and where the ground is feasible or moderately tender, they may be twenty fathoms distant; but in this, as in all other parts of Mining, the adventurers must be ruled by the varieties of place and other circumstances. An Adit Shaft should be six feet long and three feet broad, which generally employs six men to work it day and night.

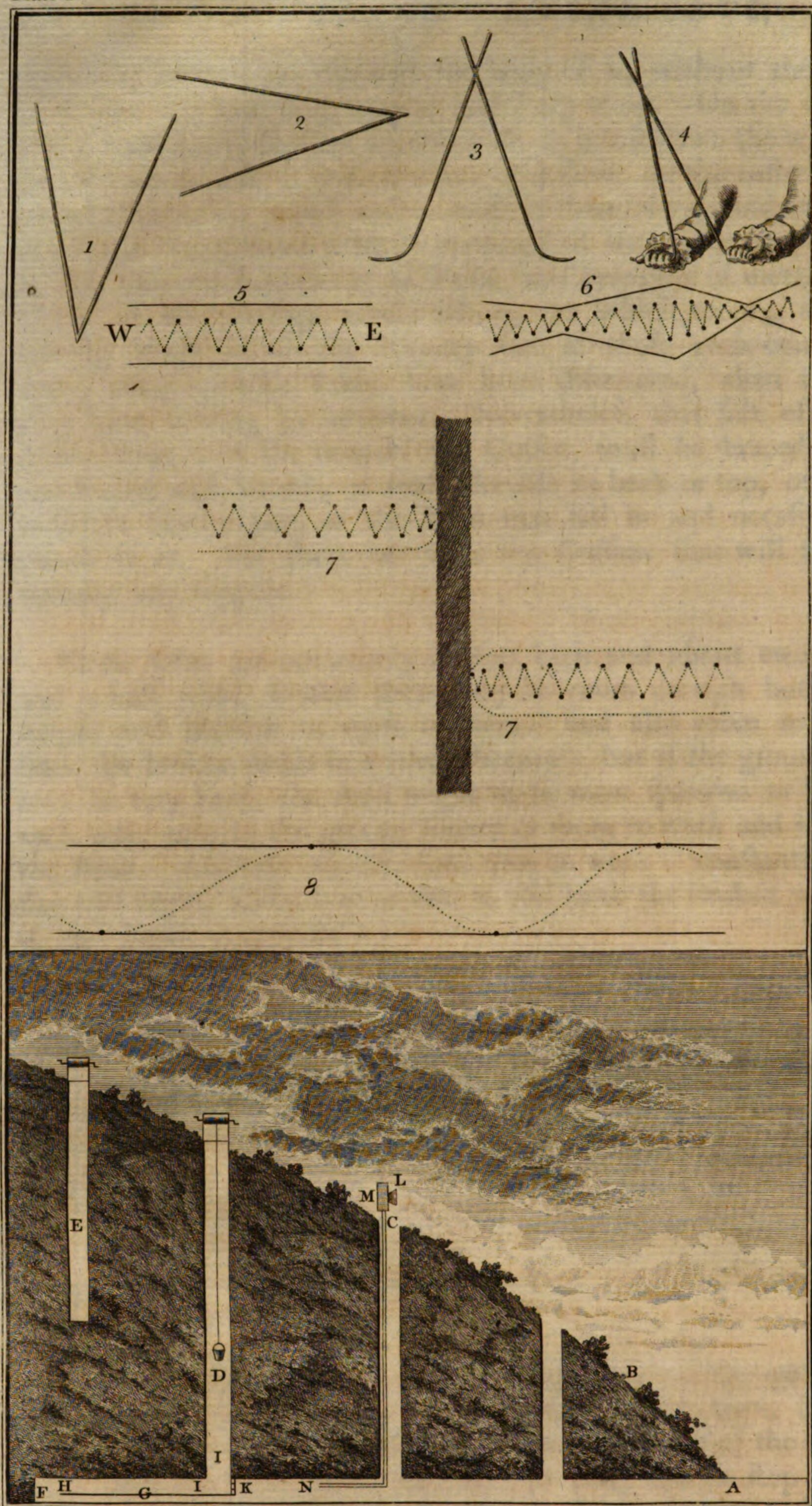
When the Miners want air by being a great way under-ground, and cannot conveniently put down a new Shaft; then, if the Adit be high enough, they lay boards on the bottom of the Adit, from their last Shaft along to the Adit end, and so stop them down closely with clay or earth, by which contrivance, called a Saller,





To the Honorable, the Members of the House of  
 Commons, the City of the Virginia Division, &c.  
 Represented in the House, as most respectfully desired, by  
 the Petitioners.





To Sir William Molesworth, of Pencarrow in the County of  
 CORNWALL, Baronet. This Plate of the Virgula Divinatoria, &c.  
 engraved at his expence, is most gratefully Inscribed, by  
 W.<sup>m</sup> Pryce.



Saller, the boards being hollow underneath, air is conveyed to the workmen.

To make these matters clear with regard to driving and Saller-ing an Adit, let us suppose A to be the lost sloan or tail of the Adit, the level from which the Adit was first driven, all open to grafs, till it took into the side of the hill B. A little further on they put down an Adit Shaft for air, or conveyance of the deads from the Adit. The next Shaft C, was sunk for the same purposes; and so was D, which is represented as the present working Shaft, for the other Shaft E is not sunk down upon the Adit end F. For want of the Shaft E being holed upon the end F, the air is very close and suffocating; nay, the Adit end must be deserted for want of air. To remedy this, they go behind the shaft D, and put in a Saller, or close stage of boards G, about one foot high from the bottom of the Adit, which is continued within five or six feet to the end at H, where it is open and discharges the air back through the Adit and up the Shaft I I, because that is totally stopped by an exceeding close door at K. There is another way of forcing down air by an air pipe, as at the Shaft C; the top of which L, can be turned towards the wind when it blows from any quarter, and receives the air which is forced down through the funnel M into the Adit at N, whence it circulates back again through the former workings.

This air pipe is seldom used in Adits, because the Saller is more cheap and easy, the difference of expence in the air pipe being considerable where an Adit Shaft is thirty or forty fathoms deep; besides, the Saller under the workmen's feet is less incommodious, than the funnel over their heads: nevertheless, this air pipe is of indispensable use in the sinking a Shaft that is void of circulation of good air, and it is seldom that a Shaft of forty fathoms depth can be sunk without an air pipe all the way down from grafs, provided the Shaft has no communication, by drift or Gunnies, with some other parts of the workings. It must be noted, that great care is requisite to stop close every crevice of the air pipe, or the Saller, with clay or pitch and oakum, so that not a breath of air shall escape. The Saller, indeed, may be covered close with turf and earth laid all round and upon it; whereby no air can have vent but at its proper place H. By duly attending to this circumstance, an Adit may be driven beyond one hundred and fifty fathoms, before a Shaft need be sunk down upon it. This is an affair of no mean consequence,



consequence, where a Shaft must be sunk very deep in exceeding hard ground.

Sir Robert Moray, in the Philosophical Transactions No. 5, has communicated a method practised at Liege for driving of Adits without air Shafts, by erecting a chimney thirty feet high, at the tail or loft slovan of the Adit, from whence an air pipe is continued through the Adit; whereby all foul air at that place is invited or drawn, by the fire, from the working part or end of the Adit unto the chimney, where it enters under the grate filled with live coal and suspended in the middle of the chimney. This may serve, where the air is rendered noxious by sulphureous or vitriolick effluvia, to carry it off by the funnel into the chimney; but in our Adits we have no vapourous fumes to discharge. With us it is an absolute want of air, or circulation thereof; so that our relief is only acquired by pouring in a fresh current of air, and continuing the circulation as freely and uniformly as possible.

The numerous little eminencies that compose the face of our country, where the Mines are situate, afford us great advantages for Adits to unwater the Veins contained in them. Though we seldom see an Adit half a mile in length, there are two or three of three times that length, and those are the longest I know of. At Friberg in Saxony, they have very extraordinary works of this kind, particularly that called the Prince's Level, one of the greatest works in those parts, considering the time, labour, and expence necessary to work a passage under-ground, for about five English miles in length.

The labour and expence of driving this level, must have been great and tedious, where it happened in such exceeding hard ground as we sometimes meet with here: for although I have known an Adit end driven several fathoms at four shillings a fathom in Pot Grouan, that is, soft grouan; yet I have paid twelve guineas for the same Adit, that we have driven many score fathoms for less than one; so various and uncertain are the strata of the earth in these parts. The greatest expence for the ground discovered, that I ever heard of in driving an Adit, was in the old Pool, two miles off, where Mr. Bassett paid five and thirty pounds  $\text{per}$  fathom for the driving of several fathoms, through an Irestone stratum; which great price answered so badly for the contractors, that they were very much injured by the undertaking. The most desirable ground to drive an Adit in,



in, where it cannot be brought home upon the Lode itself, or a cross-course, is a tender feasible Killas of eighteen shillings & fathom. This ground needs no timber to support it, and can be speedily spent or worked at the rate of eight or ten fathoms monthly.

If an Adit is set by the fathom, and the ground proves hard, the workmen are often regardless of driving in a direct straight line, and are apt to drive irregularly for the advantage of working in the fairest ground; but this makes a reckoning of more fathoms to the adventurers disadvantage, than they ought in justice to be accountable for; therefore it is the most prudent method, when an Adit is set by the fathom, to agree, that the measurement shall be on the grass or surface, because then if the workmen drive out of the way it will be their own loss.

In bringing home these levels, the natives of Cornwall never consider the expence so much as the time it may be performed in: indeed, it is an axiom in Mining, that the quicker an Adit is driven, the less must be the expence. Some levels have taken thirty years to complete them; and I have been concerned in one that took seventeen years to bring it home to the Mine. Yet notwithstanding all disadvantages, fundry levels have been carried across as meer seeking adventures, for the sake of discovery, without being bound for any particular Mine; and some of them, by patience and perseverance, have amply rewarded the enterprize.

I must allow that such adventures are very laudable; for if a level forms an horizontal acute angle with the perpendicular section of the summit of a hill, at the charge of three thousand pounds in fifteen years driving, though without the success desired, it is likely to prove an useful undertaking for posterity, who may reap the advantage of it, when they want levels to unwater veins that may be discovered in other parts of the hill. The expence of an adit is slow and small; therefore it is easily borne. Two or three hundred pounds a year in driving an Adit, is scarcely felt by eight or ten persons, than whom seldom fewer are concerned; and this too upon the chance of finding a vein, or veins, that may throw up an amazing profit presently after discovery, by an advantage in the very means of discovery itself.

Qq An



An Adit being driven home to the Mine, the water seldom fails of draining and falling into it; so that the Lode is unwatered as deep as the level of the Adit, to which depth, or yet a greater, the men are at liberty to sink and drive on the Lode if they think proper.

With all the skill and adroitness of our Miners, they cannot go any considerable depth below the Adit, before they must have recourse to some contrivance, for clearing the water from their workings. The hand pump, and the force pump, will do well for small depths, and are necessary in the first sinkings into the Lode, before the Stopes can proceed. Next to these, the water is drawn to Adit by small water barrels; but if the water exceeds a certain number of barrels, in a core of six or eight hours, they give over drawing by hand, and erect a Whym, which is a kind of horse engine to draw water or work, and sometimes both, especially in the infancy of a Mine. A common Whym which serves both purposes, consists of a perpendicular axis, whereon a large hollow cylinder of timber turns, called the Cage, round which the rope winds horizontally, being directed down the Mine by two pulleys fixed in what are termed Puppet Heads over the mouth of the Shaft: this axis has a transverse beam, called the Arm infixed; at the end of which are placed two horses that go round upon a platform named the Whym-round, and draw more or less according to the number of their circumvolutions in any given time, the largeness of the barrels, and the depth the Whym is to draw. For drawing of water, this engine can only work in a perpendicular Shaft; but for winding of work or deads, it can be used to draw upon the underlie of the Lode.

Another water engine is the Rag and Chain, which consists of an iron chain with knobs of cloth stiffened and fenced with leather, seldom more than nine feet asunder: the chain is turned round by a wheel of two or three feet diameter, furnished with iron spikes, to inclose and keep steady the chain, so that it may rise through a wooden pump of three, four, or five inches bore, and from twelve to twenty-two feet long, and by means of the leather knobs bring up with it a stream of water answerable to the diameter of the pump, and in quantity according to the circumvolutions of the wheel in any given time. Several of these pumps may be placed parallel upon different Stulls, Sallers, or Stages of the Mine, and are usually worked by hand like those in our navy. The men work at it naked excepting their loose



loose trowsers, and suffer much in their health and strength from the violence of the labour, which is so great that I have been witness to the loss of many lives by it.

A rag and chain pump of four inches diameter, requires five or six fresh men, every six hours, to draw twenty feet deep; and to keep it constantly going, twenty or twenty-four men must be employed monthly, at forty or fifty shillings each man. The monthly charge of one of these engines cannot be less than fifty or sixty pounds; and they are now pretty generally laid aside on account of the great expence, and the destruction of the men. Nevertheless the motion of the rag and chain, when it is constant, is so quick, that it will discharge a quantity of water, even exceeding that of a wheel and bob engine, whose pump is 10 inches bore; and it may be usefully applied to draw water from fundry parts, such as dippas or little pits of a Mine, which have no communication with other aqueducts to the grand machinery for delivering of the water to Adit.

Where the rag and chain pumps are unequal to the work, and too chargeable for the Mine to repay, they may have recourse to the whym again; and instead of drawing with sixty gallon barrels as at first, they may put in larger ones to the amount of 120 gallons in each barrel drawn by the additional help of two horses more. This draught must be within twenty fathoms, and not less than two barrels a minute, to be worth the charge.

The water wheel with bobs, is yet a more effectual engine; whose power is answerable to the diameter of the wheel and the sweep of the cranks fixed in the extremities of the axis. Over them two large bobs are hung upon brass center gudgeons supported by a strong frame of timber, and rise and fall according to the diameter of the sweep of the cranks, or of the circle they describe. To each crank is fixed a straight half split of balk timber, that communicates with each bob above: at the other hand or nose of the bob over the Shaft, a large iron chain is pendent, fastened to a perpendicular rod of timber that works a piston in an iron or brass hollow cylinder, called the Working Piece: the quantity of water exhausted, will be in proportion to the bore of the working piece, and the number of times which the embolus works up and down in a given space. The water engine wheel at Cooks Kitchen Mine, is forty-eight feet diameter, and works her tiers of pumps of nine inches bore, which



which being divided into four lifts, draws eighty fathoms under the Adit. If the stream of water were sufficient to fill the buckets of the wheel, she would draw forty fathoms deeper with the same bore; and I have been well informed, that the power of a forty-eight feet wheel, is equal to the diameter of a forty-seven inch fire engine house cylinder: whence this kind of engine is the most eligible, where grass water is plenty, and to be had for a small rent.

The number of stamping mills adjacent to the Mines, and the value of water for the various ablutions of Tin and Copper Ores, render every small rivulet of some considerable consequence to those through whose lands the water happens to flow. Many of our country gentlemen have made great rents of their water courses, when they have been diverted from their grist mill tenants; and some of them, without any recompence made to the lessees, have received fifty pounds a month, several years, for a small mill stream of water to drive one of those engine wheels upon Mines in their own lands.

Happy would it be for the Mining interest, if our superficial streams of water were not so small and scanty; but the situation of our Mines, which is generally in hilly grounds, and the short current of our springs from their source to the sea, prevent such an accumulation of water, as might be applied to the purpose of draining the Mines; and of course the value of water is the more enhanced. There are very few streams, which are sufficient to answer the purpose in summer, as well as in winter, so that many engines cannot be worked from May to October; which is a great loss at that season of the year, when men can work longer at grass, and with more vigour, than they can in short days and cold weather. Yet the innumerable Adits driven into the earth, afford tolerable supplies of water to those streams, and are of some importance to the unwatering of the Mines. By the superior address of our Miners, the rivulets are often extended many miles to drive an engine; and are then returned as far back again as possible, to serve other Mines and stamping mills; besides, the moisture of our air and situation, which is directly exposed to the great western ocean, as well as to the British and Bristol Channels, causes abundance of rain, and contributes not a little to swell our small rivers after the autumnal equinox.

But



But where the situation of a Mine will not admit of a water engine, or where the stream is insufficient, the last resource is that most useful, powerful, and noble machine, the fire engine, of which we have several that are perhaps the largest in the kingdom. It is the most admirable curious and compounded machine amongst all that owe their invention to the discoveries of modern philosophy, and affords the greatest advantages to mankind. The marquis of Worcester, in his century of inventions published in the year 1663, is probably the first that proposed raising any great quantities of water by the force of fire converting water into steam; but captain Savery was the first who erected an engine for this purpose in the form we have since had them, and which has been lately improved by Mr. Blakey, though not to a degree of power sufficient to unwater a deep Mine.

Mr. Newcomen, and Mr. J. Cawley, contrived another way to raise water by fire, where the steam to raise the water from the greatest depths of Mines is not required to be greater than the pressure of the atmosphere; and this is the structure of the present fire engine, which is now of about seventy years standing.

Let us suppose a pump, or tier of pumps as we say, to be twenty-five fathoms deep, whose cylindric diameter of its full column of water is seven inches and a quarter, and of the weight of 3,000 lb. Now if the rod of this pump were hung by a chain to the nose of the lever or bob, h h, as at H ; and at the other end, another power were applied, as at L, with a superior force ; the pump might be worked, and the water raised by that power. It appears, this power cannot be supplied by the strength of man, or beast ; for it will require one hundred men to pull down the bob, each pulling with the force of 30 lb, and one hundred men to relieve them when weary. But as the pump in a Mine must not stand still, there should, for such hard labour, be a fresh corps of one hundred men every four hours at least, which would amount to six hundred men every twenty-four hours. If we allow horses, and one horse equal to five men, there must be twenty horses working at a time, and twenty more to relieve them every four hours, where the draft must be so constant and excessive ; which will amount to one hundred and twenty horses every twenty-four hours ; and so great a number, though less expensive than men, will be found too great for most Mines, if it were possible to apply them



them to that use. I produce this example, to shew the prodigious force that is required to draw water in the small epitome of a Mine; for the diameter of the pump given, and the depth of twenty-five fathoms, bear the least analogy to the depth of our Cornish Mines, whose fire engine house cylinders are generally from fifty-four to seventy inches diameter. Now allowing 8 lb to each square inch, clear of friction, in the power of a fire engine house cylinder of seventy inches diameter; the number of pounds avoirdupoise within its extent of power to lift up or pull down, are equal to 30,784 lb. The human power equal to this will require the strength of 1,026 men every four hours, or 6,156 men the day and night; or 1,230 horses. A sixty inch cylinder, also, which will lift 22,616 lb, is equal to 4,518 men, or 900 horses, every twenty-four hours. Some other power therefore must be applied; which may be effected as follows. B is a large boiler, whose water, by the fire under it, is converted into an elastick steam. (See plate III) The great cylinder C C is fixed upon it, and communicates with it by the pipe D d; on the lower orifice of which, within the boiler, moves a broad plate, by means of the steam cock, or regulator E 10, stopping or opening the passage to prevent or permit the steam to pass into the cylinder, as occasion requires. The diameter of the pipe D is about four inches.

The steam in the boiler ought always to be a little stronger than the air, that, when let into the cylinder, it may be a little more than a ballance to the external air, which keeps down the piston at the bottom d n. The piston being by this means at liberty, the pump rod will, by its great weight, descend at the opposite end to make a stroke, which is more than double the weight of the piston, &c. at the other end. The end of the lever at the pump, therefore, will always preponderate and descend, when the piston is at liberty. The handle of the steam cock E 10, being turned towards n, opens a pipe D to let in the steam; and being turned towards O, it shuts it out, that no more can enter. The piston is now raised towards the top of the cylinder at C, and the cylinder is full of steam. The lever O 1 must then be lifted up, to turn, by its teeth, the injecting cock at N, which permits the water, brought from the cistern g by the pipe g M N, to enter the bottom of the cylinder at n, where it flies up in the form of a fountain, and striking against the bottom of the piston, the drops, being driven all over the cylinder, will, by their coldness, condense the steam into water again, and precipitate it to the bottom of the cylinder.

Mr.



Mr. Beighton made an experiment to determine the rarity of steam, and found the content of a certain cylinder of steam was 113 gallons; and since there were 16 strokes in a minute, therefore  $113 \times 16 = 1808$  gallons of steam  $\phi$  minute. He also observed, that the boiler proportioned to that cylinder, required to be supplied with water at the rate of five pints  $\phi$  minute: and since 282 cubick inches make a gallon,  $35\frac{1}{4}$  make a pint, and  $5 \times 35\frac{1}{4} = 176\frac{1}{4}$  in five pints: also the cubick inches of steam are  $1808 \times 282 = 509856$ ; if then we say, as  $176\frac{1}{4} : 509856 :: 1 : 2893$ ; or one cubick inch of water is expanded into 2893 inches of steam; consequently the steam in the cylinder is reduced to  $\frac{1}{2893}$  part, when turned to water by the jet of cold water; and therefore a sufficient vacuum is made in the cylinder, for the piston to descend, unballanced, by the pressure of the atmosphere. The piston being forced down, raises the other end of the lever or bob, and consequently the box of the pump under-ground, which brings up and discharges the water at adit, the same as at p. Now this whole operation of opening and shutting the steam regulator and injection cock, will take up but little more than three seconds; and will, therefore, easily produce 16 strokes in a minute.

That the cistern g may always be supplied with water, there is an arch fixed near the arch or nose of the bob H, from whence another pump rod k, with its box and valve, draws water from the level of the adit in the same engine shaft, and forces it up the pipe m m m into the cistern g, which, therefore, can never want water.

That the leathers of the piston C may be always supple and swelled out, so as to be constantly air tight, a small stream of water is supplied from the injecting pipe M by the arm Z. On the top of the cylinder is a larger part or cup L, to hold the water that lies on the piston, lest it should overflow when the piston is got to its greatest height, as at W; at which time, if the cup be too full, the water will run down the pipe V to the waste well at Y.

The water in the boiler, which wastes away in steam, is supplied by a pipe I i about three feet long, going into the boiler a foot below the surface of the water. On the top of this pipe is a funnel I, supplied by the pipe W with water from the cup of the cylinder, which has the advantage of being always warm, and therefore not apt to check the boiling of the water. That the



the boiler may not have the surface of the water too low, which would endanger bursting; or too high, which would not leave room enough for steam; there are two gage pipes at G, one going a little below the surface of the water when at a proper height, and the other standing a little above it. When every thing is right, the stop cock of the short pipe being open, gives only steam, and that of the long one water; but, if otherwise, both cocks will give steam when the surface of the water is too low, and both give water when it is too high; and hence the cock which feeds the boiler at I, may be opened to such a degree, as always to keep the surface of water to its due height.

The cold water, constantly injected into the cylinder to condense the steam, is carried off by the eduction pipe d T Y, leading from the bottom of the cylinder to the waste well Y, where going a little under water, it has its end turned up, with a valve Y, to keep the air from pressing out into the pipe, but permitting the injected water coming the other way to be discharged, whereby the cylinder is kept empty.

Left the steam should grow too strong for the boiler, and burst it, there is a valve fixed at h, with a perpendicular wire standing up from the middle of it, to put weights of Lead upon, in order to examine the strength of the steam pushing against it from within. Thus the steam is known to be as strong as the air, if it will raise up so much weight on the valve, as is at the rate of fifteen pounds to an inch square, because that is the weight of air, nearly, on every square inch. When the steam becomes stronger than is required, it will lift up the valve, and go out: this valve is called the Puppet-Clack. The steam has always a variable strength, yet never one-tenth stronger or weaker than common air; for it has been found, that the engine will work well when there is the weight of one pound on each square inch of the valve: this shews, that the steam is then one-fifteenth part stronger than the common air. Now as the height of the feeding pipe, from the funnel F to the surface of the water G s, is not above three feet, and three feet and a half of water is one-tenth of the pressure of the air; if the steam were one-tenth part stronger than air, it would push the water out at E; and since it does not, it cannot be stronger than air, even in this case, where, the regulator being shut, it is most of all confined. When the regulator is opened, the steam gives the piston a push, which raises it up a little way; then filling a greater space, it  
comes



comes to be of the same strength with, and so a ballance to, the atmosphere: thus the piston, being at liberty, rises to the top W. The steam, now expanded into the whole capacity of the cylinder, is weaker than the air; and would not support the piston, were it not for the greater weight at the other end of the lever, which keeps it up. The steam, each stroke, drives the injected water of the preceding stroke out of the eduction pipe d T Y; and would itself follow, and blow out at the valve Y, which is not loaded, if it were stronger than the air, which it never does. If it were exactly equal to the strength of the air, it would just drive all the water out at Y; but could not follow itself, the pressure being equal on each side the valve by supposition. If it be weaker than the air, it will not force all the water out of the pipe at d T Y; but the surface will stand, suppose at T, where the column of water T Y, added to the strength of the steam, is equal to the pressure of the air. When the steam is one-tenth weaker than the air, the height T Y = three feet and a half. Now, since the whole perpendicular distance from d to Y is but four feet, and the steam always sufficient to expel the water; it is plain, it can never be more than one-tenth part weaker than the air, when weakest.

There is air in all the water injected; and though that air cannot be taken out or condensed with the steam, yet will it precipitate through the steam to the bottom of the cylinder, as being much heavier: for steam is to water, as 1 to 2893, in its density; but the density of air is to that of water, as 1 to 864 nearly; therefore the rarity of steam is to that of air, as 2893 to 864: the air will, therefore, fall through the steam to the bottom, and from thence be driven out through a small pipe opening into the cup at 4, on which is a valve. Now when the steam first rushes into the cylinder, and is a little stronger than the outward air, it will force the precipitated air to open the valve at 4, and make its escape; but the steam cannot follow, because it is weaker than the outward air, as the piston gives it room, by ascending, to expand. This valve, from the noise it makes, is called the Snifting-Clack.

Among the great improvements of this engine, we may reckon that contrivance by which the engine itself is made to open and shut the regulator and injection cock, and that more nicely than any person attending could possibly do it. For this purpose, there is fixed to an arch 12, at a proper distance from the arch P, a chain, from which hangs a perpendicular piece or working  
S f
beam



beam *Q Q*, which comes down quite to the floor, and goes through it in a hole, which it exactly fits. This piece has a long slit in it, and several pin holes and pins, for the movement of small levers destined to the same office of opening and shutting the cocks, after the following manner: between two perpendicular pieces of wood, on each side, there is a square iron axis *A B* (plate III, fig. 2) which has upon it several iron pieces of the lever kind. The first is the piece *C E D*, called the *Y*, from its representing that letter, inverted by its two shanks *E* and *D*; on the upper part is a weight *F* to be raised higher or lower, and fixed, as occasion requires. This *Y* is fixed very fast upon the said iron axis *A B*.

From the axis hangs a sort of an iron stirrup *I K L G*, by its two hooks *I G*, having on the lower part two holes *K L*, through which passes a long iron pin *L K*, and keyed in the same. When this pin is put in, it is also passed through the two holes, in the ends *E N*, of the horizontal fork or spanner *E Q N*, joined at its end *Q* to the handle of the regulator *V* 10. From *Q* to *O* are several holes, by which the said handle may be fixed to that part of the end which is most convenient. Upon this axis *A B*, is fixed, at right angles to the *Y*, an handle or lever *G 4*, which goes on the outside of the piece *Q 2*, *Q 2*, and lies between the pins. Another handle is also fastened upon the same axis, viz. *H 5*, and placed at half a right angle to the former *G 4*; this passes through the slit of the piece *Q 2*, *Q 2*, lying on one of the pins. Hence we see, that when the working beam goes up, its pin in the slit lifts up the spanner *H 5*, which turns about the axis so fast as to throw the *Y*, with its weight *F*, from *C* to *6*, in which direction it would continue to move, after it had passed the perpendicular, were it not prevented by a strap of leather fixed to it at *æ*, and made fast at the ends *m* and *n* in such a manner as to allow the *Y* to vibrate backwards and forwards about a quarter of a circle, at equal distances, on this side and that of the perpendicular.

In the representation we have given, the regulator appears open, its plate *T Y* being shewn on one side the pipe *S*, which joins the cylinder and boiler. The piston is now up, and also the working beam near its greatest height; the pin in the slit has so far raised the spanner *H 5*, that the weight *F* on the head of the *Y* is brought so far from *n*, as to be past the perpendicular, and ready to fall over towards *m*, and, when it does so, it will by its shank *E*, with a smart blow, strike the iron pin *K L*,  
and



and drawing the fork horizontally towards the beam Q, will draw the end 10 of the regulator towards 6, and shut it, by flipping the plate Y under the holes of the throat pipe S. Immediately after the regulator is shut, the beam rising a little higher, with its pin s on the outside upon the lower part, lifts up the end k 1 of the handle of the injection cock, and opens it by the turning of the two parts with teeth. The jet immediately making a vacuum, the beam again descends, and the pin r depressing the handle k 1, shuts the injection cock; and the beam continuing to descend, the pin p bears down the handle G 4, and throwing back the Y, its shank D throws forward the fork N Q, and again opens the regulator to admit fresh steam. All the parts now begin afresh to operate; and thus is the engine most wonderfully contrived to work itself. After the engine had been made, as above described, for many years, it received another improvement of very great advantage; and that was, instead of feeding the boiler with warm water from the top of the cylinder by the pipe W (fig. 1) above, and F f below, it was supplied with the scalding hot water which comes out of the eduction pipe d T Y, which now, instead of going to the waste well at Y, was turned into the boiler on the top part; and as the eduction pipe before went out at the side of the cylinder, it was now inserted in the bottom of the same: and though the pressure of steam in the boiler, be somewhat greater in the cylinder, yet the weight of water in the eduction pipe being added to the force of steam in the cylinder, will carry the water down continually, by overcoming the resistance in the boiler. (Martin.)

To this description of the fire engine, I shall add a most curious and useful table of the calculation of the power of fire engines for the various diameters of the house cylinder, and bore of the pump or pit-barrel, that are capable of raising water, at any depth between 2 and 876 fathoms. It was composed by Mr. John Nancarrow, jun. and is founded on this principle, that the ale-gallon of 282 cubick inches of water, weighs ten pounds three ounces, avoirdupois; and a superficial square inch is pressed with the weight of fourteen pounds thirteen ounces of air, when of a mean gravity. But allowing for several frictions, and to give a considerable velocity to the engine, it is found by experience, that no more than eight pounds of pressure must be allowed to an inch square on the piston in the cylinder, that it may make about sixteen strokes in a minute, about six feet each stroke. The use of this table is easy: if I want to know the  
power



power of a 60 inch. house cylinder, to work a pit-barrel or working piece of 12 inches diameter; I look in the first column for the diameter of the house cylinder, till I find the No. 60: I then go on in that line to my right, till I come under 12 of the uppermost line, which is the diameter of the pit-barrel or working piece, and there find 79, the number of fathoms an engine of that power will draw; that is, a house cylinder of 60 inches diameter, will draw with a 12 inch. box, 79 fathoms.

The Mine being supplied with a power for the discharge of the water, and the adventurers resolving to prove it at a good depth, they sink down the engine Shaft continually, or keep it lower than their workings upon the course of the Lode, with which it has always a deep communication, that the water may readily flow to the engine pumps, and be drawn to Adit. The bottom of the engine Shaft, while it is deeper than the workings upon the Lode, is properly the Sump or Sink of the Mine; and this should ever be the case, for the Mine to be in regular course of working: but when an engine is worked to the full extent of its power, it is common to sink a Sump in the Lode itself, and draw the water from thence by a force pump (or any more convenient hand machinery) into the engine Shaft; this, however, is seldom done unless a Mine is soon to be set idle. If the Lode underlies north, the engine Shaft ought to be at a good distance north from the back of the Lode; because, while the engine is drawing the water out of the Shaft, the Lode is still coming nearer to it by every fathom of Lode or ground that is broke away, until at last the Lode underlies into the Shaft itself; and in process of further sinking the Mine, the Lode which was before to the south of the Shaft, is gone through to the north of it; so that the deeper either of them is sunk, they are more and more distant from each other, and become at last very expensive and incommodious from the unavoidable necessity they are under, of continually driving a Cross-cut, or Drift, from one to the other, that the water may flow into the Sump for its discharge to Adit. This is an evil that cannot be prevented; for, in all deep Mines, their engine Shafts, at last, must be very distant from their Lodes, unless the underlie is trifling, and the Lode very little removed from a perpendicular. This Cross-cut or Drift of Communication is sometimes very tedious and expensive, where the ground is hard, the water quick, and the engine almost at the extent of its power.

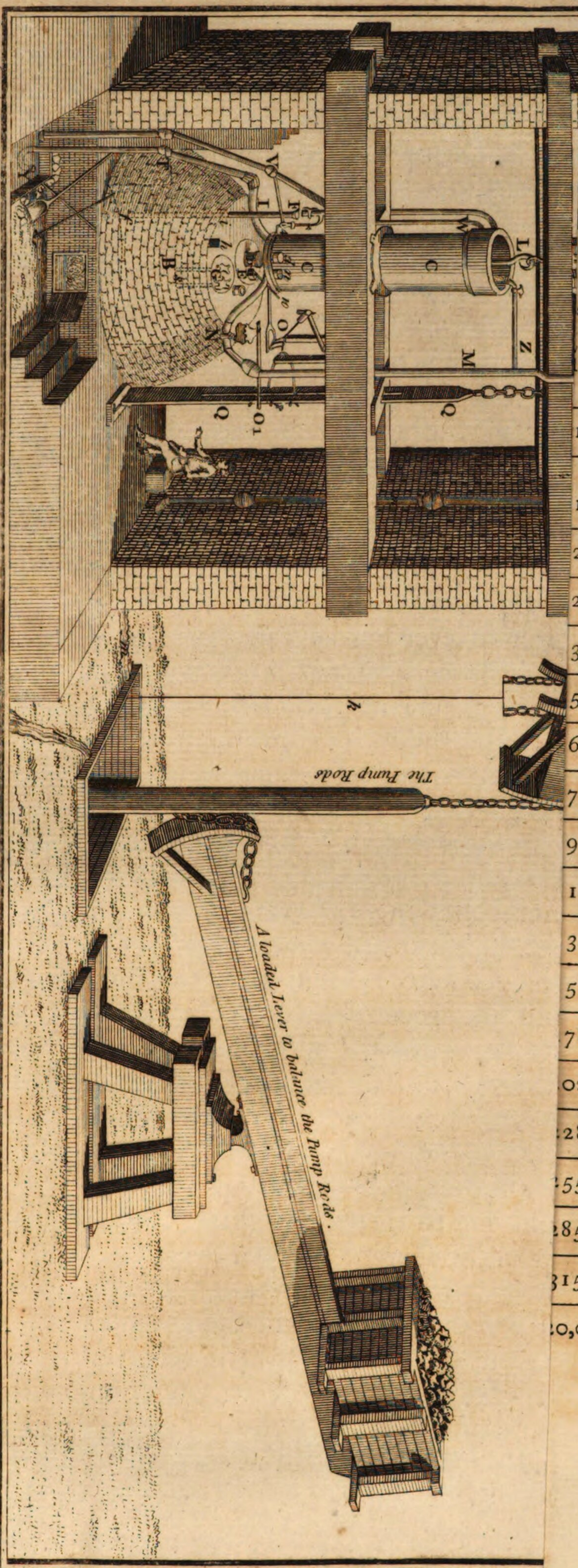
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| 20    | 1    |
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| 39    | 3    |
| 50    | 4    |
| 64    | 5    |
| 79    | 6    |
| 96    | 7    |
| 114   | 9    |
| 134   | 11   |
| 155   | 12   |
| 178   | 14   |
| 202   | 16   |
| 228   | 18   |
| 255   | 21   |
| 285   | 23   |
| 315   | 26   |
| 30,04 | 24,2 |



The Pump Rods

A loaded Lever to balance the Pump Rods

To John Price, of Esq. late  
This Section of a STEAM FIRE ENGINE  
Gratefully Inscribed by his



High Sheriff for the County of Cornwall.  
ENGRAVED at his Expense & is most  
Affectionate Kinsman Wm Price



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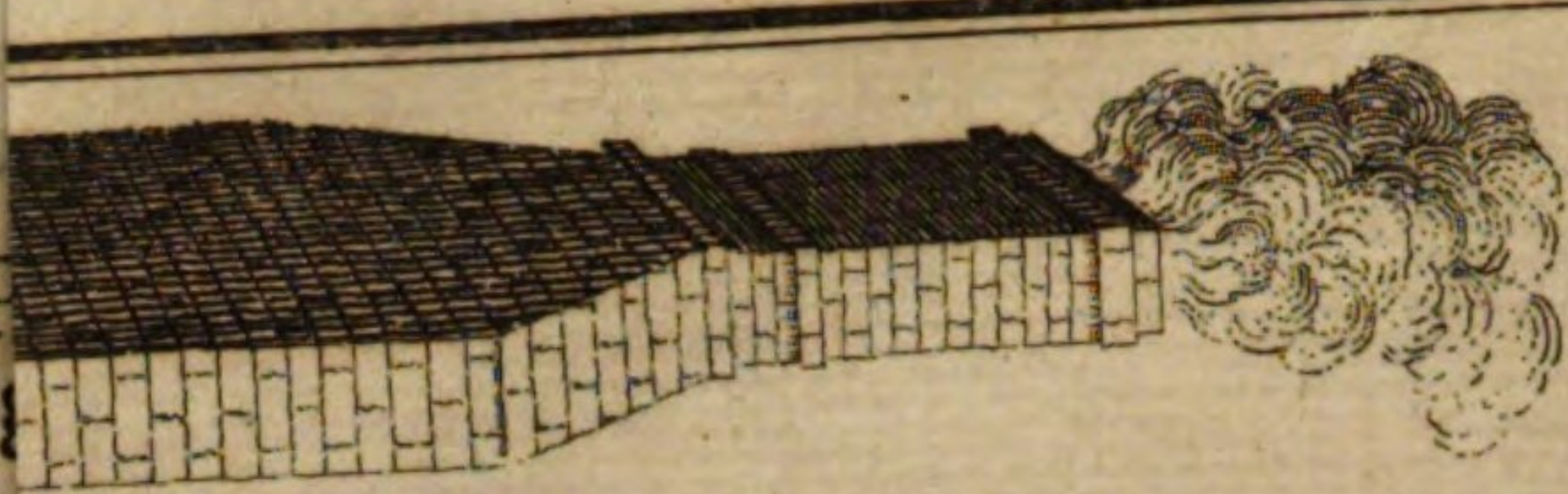


Plate 3.

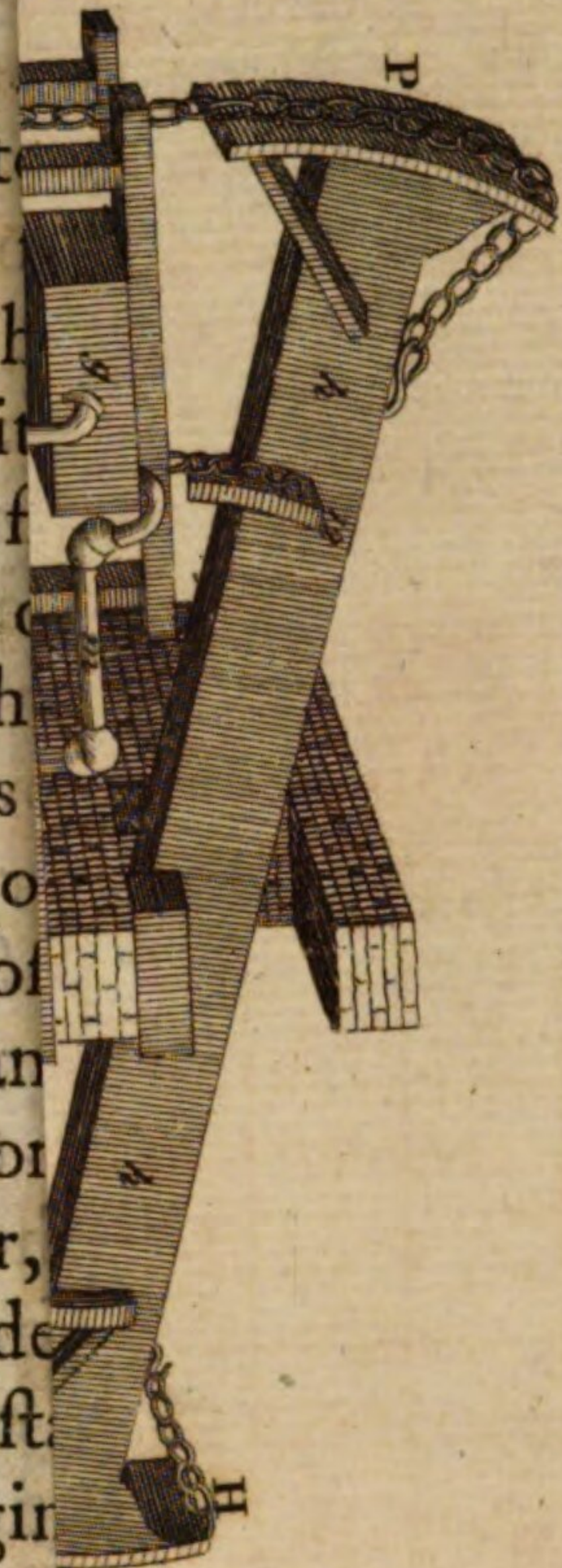


Fig. 1.

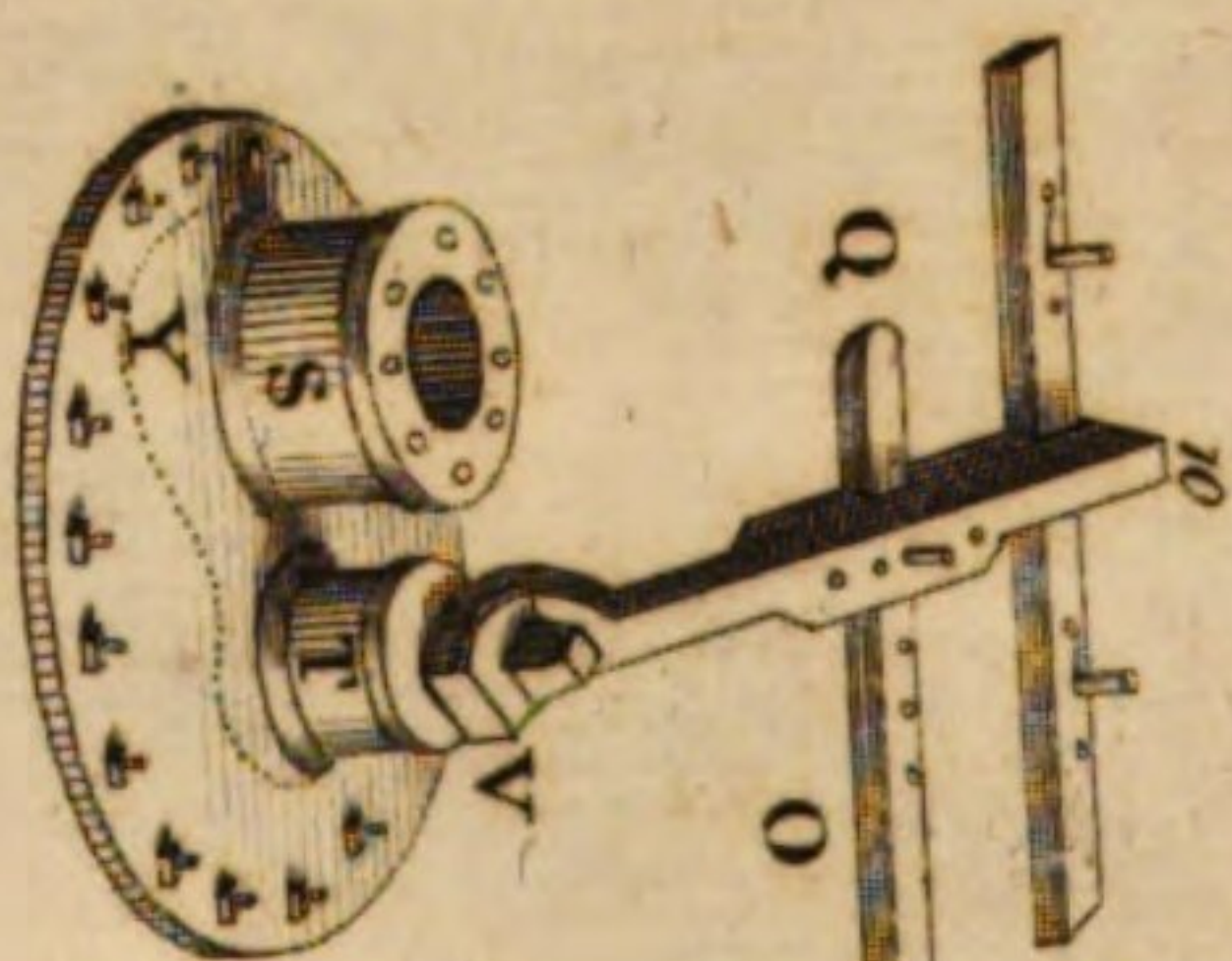
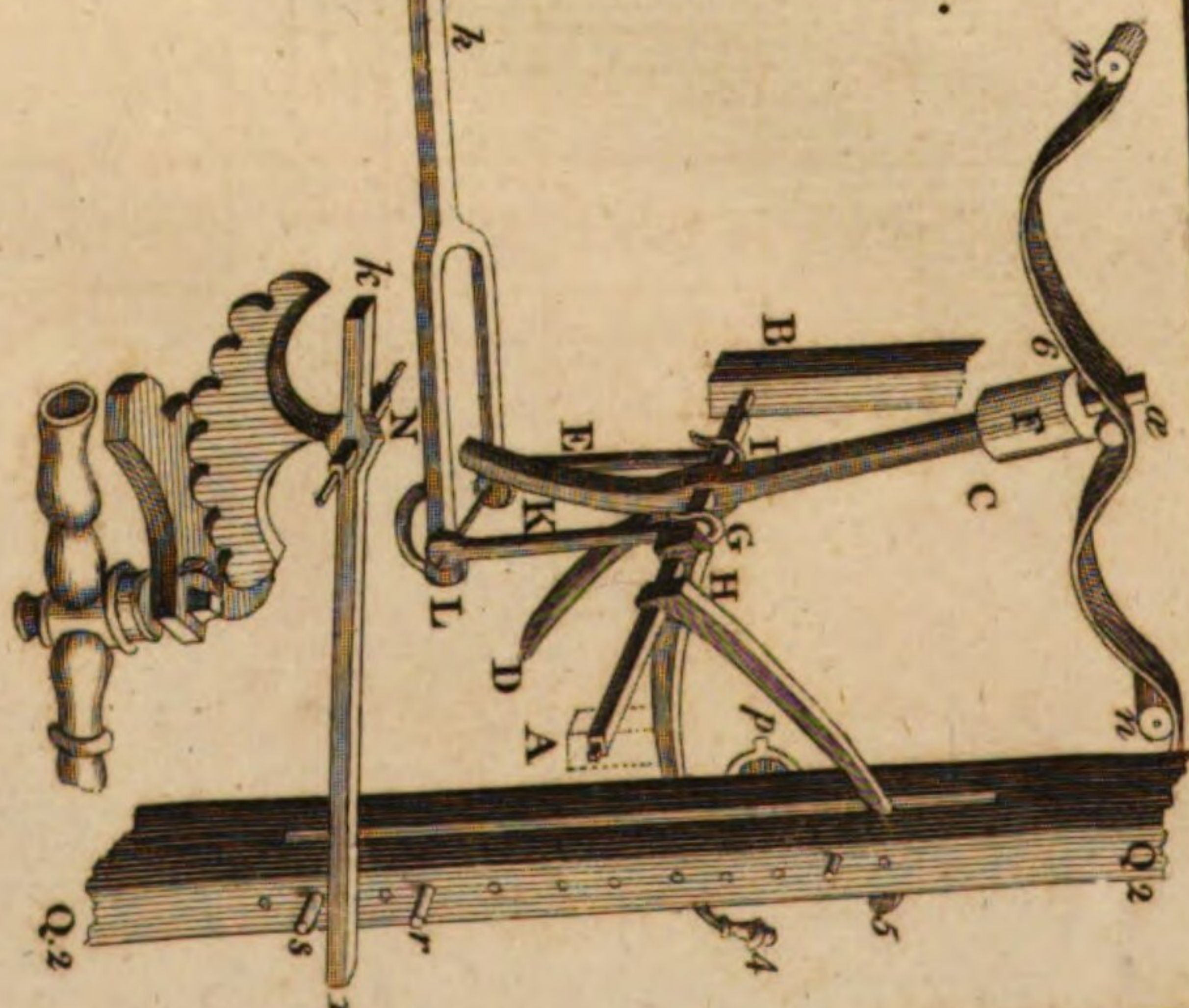


Fig. 2.





A T A B L E, shewing, at one Vi  
 20 to 100 Inches; the Areas, in  
 Pounds, Avoirdupois, such Cylinde  
 to which are added, the different  
 with Pit-Cylinders or Working-Piec  
 is given the Number of Ale-Gallon  
 fix Feet Stroke; and the last Colum  
 in the whole Tier or Lift of Pump  
 200 Inches diameter.

| Diameter of<br>the Houfe-<br>Cylinder. | Its Area<br>in<br>square Inches. | N <sup>o</sup> of Pounds<br>Avoirdupois al-<br>lowing 8 lb. to<br>every sq. Inch. | Diameter |      |       |                  |                  |      |
|----------------------------------------|----------------------------------|-----------------------------------------------------------------------------------|----------|------|-------|------------------|------------------|------|
|                                        |                                  |                                                                                   | 6 In.    | 7    | 8     | 9                | 10               | 11   |
|                                        |                                  |                                                                                   | Fath.    |      |       |                  |                  |      |
| 20                                     | 314                              | 2,513                                                                             | 35       | 26   | 20    | 15 $\frac{1}{2}$ | 12 $\frac{1}{2}$ | 1    |
| 25                                     | 490                              | 3,920                                                                             | 55       | 40   | 31    | 24 $\frac{1}{2}$ | 20               | 1    |
| 30                                     | 706                              | 5,648                                                                             | 79       | 58   | 44    | 35               | 28               | 2    |
| 35                                     | 962                              | 7,696                                                                             | 108      | 79   | 60    | 48               | 39               | 3    |
| 40                                     | 1256                             | 10,048                                                                            | 140      | 103  | 79    | 62               | 50               | 4    |
| 45                                     | 1590                             | 12,720                                                                            | 178      | 131  | 100   | 79               | 64               | 5    |
| 50                                     | 1963                             | 15,704                                                                            | 218      | 162  | 123   | 97               | 79               | 6    |
| 55                                     | 2375                             | 19,000                                                                            | 265      | 196  | 149   | 118              | 96               | 7    |
| 60                                     | 2827                             | 22,616                                                                            | 316      | 233  | 178   | 141              | 114              | 9    |
| 65                                     | 3318                             | 26,544                                                                            | 371      | 273  | 208   | 165              | 134              | 11   |
| 70                                     | 3848                             | 30,784                                                                            | 430      | 316  | 242   | 191              | 155              | 12   |
| 75                                     | 4417                             | 35,336                                                                            | 495      | 364  | 277   | 220              | 178              | 14   |
| 80                                     | 5026                             | 40,208                                                                            | 560      | 413  | 316   | 250              | 202              | 16   |
| 85                                     | 5674                             | 45,392                                                                            | 634      | 467  | 356   | 282              | 228              | 18   |
| 90                                     | 6361                             | 50,888                                                                            | 710      | 522  | 400   | 316              | 255              | 21   |
| 95                                     | 7088                             | 56,704                                                                            | 792      | 583  | 446   | 353              | 285              | 23   |
| 100                                    | 7854                             | 62,832                                                                            | 876      | 646  | 494   | 390              | 315              | 26   |
|                                        |                                  |                                                                                   | 7,22     | 9,82 | 12,82 | 16,24            | 20,04            | 24,2 |







From the level of the Sumph if it is out of the Lode, or from the Sumph itself if it is in the Lode, they turn house, and drive on the course or body of the Lode to break Ore, or to see if they can meet with any in extending the bottom or deepest part of the Mine.

Now if the Sumph proves good for Ore, they not only turn house, in order to make room and lengthen the bottom of the Mine; but they likewise stope or break away the Lode in the following manner: the Sumph being in the Lode, one man with a pick-axe breaks away about two feet of the upper part of the edge of the Sumph or pit, still driving on, on the course of the Lode; and when he makes room, another follows him in like manner, and then others; so that this stoping is not unlike the hewing a flight of steps in a rock, where each man works away the step above that which he stands on.

But if the Ore is not generally plenty in the Lode, and only in uncertain branches, then they often follow these branches of Ore, both upwards and downwards. Those small pits they make in digging down after the Ore, and all other pits that are made below in following the Ore, though they are large, are all called Dippas, provided they are not deeper than the Sumph, nor sunk down to drain the Mine as Sumphs are. But this way of sinking many Dippas, is apt to disorder a Mine, and put it out of a regular course of working; and often prevents the discovery of Ore, which may lie hid in many places in a Mine, that do not seem worth the charge of breaking that part of the Lode which appears poor and barren; however, if a Mine is on the point of being left off, then it cannot be improper to work in Dippas, where the Ore lies, in order to make the most of it.

It often happens that a Lode five or six feet wide, may have a branch or leader on one side of it, very rich for Tin or Copper, while the rest of the Lode is very poor and dry. This rich part may be one foot wide, or it may be scarcely six inches; so that if it is not a working big, or there is not sufficient for a man to work on Ore exclusive of the barren part, he breaks down, if in an end, or digs up, if under his feet, all the poor part by itself, in length, or depth, according as he chuses, or is directed; whereby the rich Ore is left standing clean from any other mixture: this he afterwards breaks and keeps by itself, whence it is then brought up to cleanse and dress.

T t

This



This separation or breaking the bad from the good Ore, they call Dyzhuing the leader, or making a Dyzhu; and the good Ore that is thus exposed, is called a Dyzhu, from the Cornish British Dyzhui, to discover unto. This method of proceeding is very useful, to prevent the more valuable part of the Lode from being mixed promiscuously with the barren part, which would increase the charges of dressing the Ore, and of consequence diminish its value by the deads and waste that would necessarily be mixed with it if the Lode was broken altogether.

But though the utility of this method must be very obvious to the reader, Dizhuing the Lode in whole, is popularly understood in the following manner: when the whole Lode is rich, and perhaps not above six or twelve inches big, it will be impossible to break the Lode away clean and free from waste of the adjoining country without it is first Dizhued: accordingly they observe which of either wall or side of the Lode is the most fair, and easily to be broken, and pursuant to that or any other contingent circumstance, they break down first of all some part of one wall and contiguous stratum by the Lode, as hath been before described, and afterwards the Lode being thus far Dizhued is taken down clean by itself. On the contrary, if one part of the Lode is very rich and fair, but small, and the rest of it is dry, barren, large, and hard, they commonly dig out first the pith or richer part of the Lode, which they call Hulking the Lode; so that in such case, the poor part which is left standing may not improperly be named a Dyzhu of the dead unprofitable part of the vein; which, if it is very hard, they usually destroy or break down by a charge of gunpowder.

For the more easy comprehension of the reader, it is to be observed, that Hulking of Lodes, is the term most generally used in driving a high end, or sinking a high stope of the Lode; and that Dyzhuing the Lode or the Leader, is most used where the barren part of the Lode, or the adjoining country, is very fair, or more so than the rich part of the vein. The interchange of terms, arises from the converse of the foregoing contingencies; for Hulking the Lode, is only useful where the country, or barren part of the vein, is much harder than its richer parts.

In Dyzhuing or Hulking the Lode, a super abundant quantity of deads must consequently incommode the workmen, and fill up the Mine, if not speedily drawn up to grafs or disposed of in some vacant place. The drawing such portions up to the surface,



surface, must be very tedious, and as costly as drawing up equal quantities of the richest Ores. Now in order cheaply and speedily to dispose of their refuse or deads, if the Mine has been worked any tolerable depth, they lay over their heads, across the fissure or evacuated workings, great beams of timber mortised into the solid rock; and across upon those beams, firm planks of deal, which make a stage or gallery, denominated a Stull, from the British word *Astel* a board or plank. Several of these Stulls are made in different depths of Mines, that are of any standing; and we find they are many ways useful to the Mine and workmen; for by such coverings over head, the workmen are oftentimes preserved from great danger by the falling of Scals, or the tumbling down of rocks and stones from various places of the workings over them. These Stulls are doubly useful to the Mine; for all the deads or refuse part of the workings before mentioned, are conveniently thrown to Stulls, as they say, to the saving of much labour and great expence; and at the same time, when thus filled with Attal or deads, they help to prop or keep open the Mine from being crushed together by the incumbent strata or country. One only inconvenience, that I know of, results from the making of Stulls in a Mine; that is, they often serve for concealing Ore under-ground, which the combined knavery of the workmen, with the connivance of the captains, may place there till it suits their opportunity to remove it for their own advantage to mix with Ore upon tribute, where they are largely concerned. All publick undertakings are more exposed than private ones, to the peculations of dishonest servants.

In some Mines, where Ore is broken more speedily than it can be drawn up to grafs, (and I have known some Lodes so fair and rich that one pick-man would keep a whym constantly going) it is necessary for them to have a place under-ground, distinct from the Shafts and Stopes of the Lodes, for lodging their Ore, till they are at liberty to bring it to grafs; particularly where they are driving a drift either upon Ore or deads. This place, if it is dug out of the solid rock or country, they call a Plot, or cutting a Plot. The Plot (commonly called the Plat) is seldom under twelve feet square and six feet high; but it may be much larger according as circumstances require. At the entrance or beginning of almost every Drift, a Plot, or chamber, is convenient to lodge the broken stuff on, almost as soon as it is broke, that it may not incommode the working of the drift end; and it is also more necessary at the top of the  
Little-



Little-Winds or under-ground Shaft, that communicates with the side or bottom of the upper or graft Shaft. It may appear strange to some of my readers, how Shafts under-ground, like those above, can be necessary or even practicable; but it is very true, that few Mines are without many of them; and that, in the workings of former times, they were more numerous than graft Shafts.

The under-ground Shaft or Winds, is worked by hand, with a windlass only; and its area is not so large as the graft or working Shaft; whence it is corruptly abbreviated the Little-Winds. Now that we may understand how necessary the Little-Winds is to the working of a Mine, the reader will be pleased to remember, what I have before hinted, that Lodes in their underlie, go away from the Shafts, in which the work or Ore is brought up: the Shafts are thereby rendered useless in course of time, and therefore it is commonly requisite to sink down new Shafts, and cut the Lode at a deeper underlie, that they may draw up the work perpendicularly with greater facility. But those Shafts in deep Mines, are often costly, and troublesome to be sunk, from the surface of the earth; either by means of the water that falls into them, the intense hardness of the stratum they must cut through in sinking, or by means of loose soft ground, that requires much timber and boards to line the Shaft from top to bottom. When they find any of these difficulties very great, they sink a Little-Winds in this manner: they go down in the graft Shaft, from whence the Lode is gone so far as the Shaft is perpendicular, or as far as they think proper; from thence they work in a drift or horizontal line, till they come as far over the underlie of the Lode, as they like: there they cut a Plot; and in the middle of this Plot they fix a windlass or winding tackle, and sink down their Little-Winds or Shaft until they cut the Lode in it, or to the depth they intended. If the Plot is not sufficiently large after the Winds is sunk, they make it wider, for holding the work they wind up from the deeper workings; whence the men roll it away in wheel-barrows to the graft Shaft, where is another Plot, Saller, or stage of boards, to place it on, from whence they draw it up to the surface at their leisure. Hence it appears, that both the graft Shaft, and Little-Winds, are put down in strait lines; and they would be parallel to each other, had the Winds been continued up to the graft or surface; but the line, or drift of communication common to both, is horizontal and at right angles



angles to each other ; and goes from the foot or side of the graft Shaft, to the top of the Winds.

We may conclude, that the number and necessity of these under-ground Shafts in a Mine, greatly depends upon the horizontal tendency of the Lode : for if a vein goes down nearly perpendicular, the graft or working Shaft will answer its purpose very well ; but if it inclines fast, or underlies a fathom in a fathom, that is, if for one fathom in perpendicular depth which the Lode is sunk upon, it is gone likewise a fathom to the north or south, the use of the Winds soon becomes necessary. And though there is a great expence in sinking these under-ground Shafts, and cutting of Plots, yet their usefulness counterballances it, where a great waste of ropes and expence of draft are occasioned by dragging upon the long and flat underlie of a deep Mine. In deep Mines, some whym ropes cost fifty or sixty pounds ; and perhaps cannot be used with safety beyond two months if daily employed, on account of the great wear by dragging fifty or sixty fathoms upon the inclination of the Lode ; besides the expence of putting four horses to draw half the work, which two, but for the depth and impediment, might perform ; it being well known, the Kibbal in such cases seldom comes up half full to grafts. Nevertheless, these with many other difficulties are to be borne with in deep Mines inclosed by dense strata ; and it must of consequence follow, that the Winds is more eligible in a fair and feasible country.

When a Mine is wrought very deep, it requires too much time to let many men down through the working Shaft, which is appropriated to the bringing the work or Ore to grafts ; and therefore their underlying Shafts, which are become useless, and out of course of working, are converted into a foot way. To make a good foot way, they build a Saller or landing plot of boards, on which they rest the foot of a long ladder, the other end whereof reaches up to the top of the Shaft at the surface ; then, from the foot of the ladder, they have an horizontal passage to another deeper Shaft on the underlie of the Lode, where they have another Saller or landing place, and fix another ladder to descend deeper ; and thus they proceed, till they have ladders enough to go down to the bottom of the Mine. Yet it is very common in great Mines to have foot ways by ladders in their engine Shafts, which not only serve the purpose of going down into the Mine, but also of inspecting every



crevice of the pumps that have lost water, that they may rectify them when any misfortune happens. Those ladders in the engine Shafts are of various lengths; but at the foot of each ladder there is placed a Saller for it to rest upon, above which, the top of the next ladder presents itself.

Either in driving an Adit, or sinking a Shaft in loose mouldering stratum or country, they are often obliged to bind and secure them with timber, to prevent the country from running into the workings, and thereby choaking them. If the ground is very loose on all sides, they make a Durns, as they call it, which for a Shaft is square like the frame of a window, and for an Adit is the same as a door case. Between the Durns and the country they thrust in deal boards, whose extremities lengthways are just placed behind each Durns; by which means the loose ground is kept secure from filling the workings and destroying the men. This, in an Adit, or any other drift, is called Binding or timbering of it; but in a Shaft, it is Collaring the Shaft; and indeed every Shaft, before it is sunk into the hard rock, or while it is in the rubble of the country, must be thus Collared; and the top is thence usually denominated The Collar of the Shaft.

All deep Mines likewise require to be well propped and supported with stemples or massy pieces of wood, which being boarded over make Stulls, as I have already observed. These stemples or pillars of wood, which some call Lock-pieces, are generally placed perpendicularly, one end being fixed under the upper or hanging wall of the Lode, the other end resting on its underlying wall; so that these pillars sustain and keep up, not only the roof or hanging wall of the Lode, but also the prodigious weight of the impending strata or country. I have seen those massive pillars crushed almost together in some Mines, by their incumbent roof, and have been filled with horror at their appearance; and in other Mines, where the Lode has been wide and but little inclined, they have appeared like the pillars which form the aisle of a venerable piece of Gothick architecture. But to save the charge of the timber, and cost of breaking the fruitless part of the vein, they often leave pillars of the Lode unbroken and standing, especially if they are poor in nature, and of a hard stony consistence; and by driving holes through those pillars, which are called Arches of the Lode, they preserve a communication with the rest of the workings.

It



It requires much judgment to know when to use timber, and when to do without it; for an unskilful person may at a great charge use timber where it is not wanted; or may apply it so injudiciously, that it may not answer the purpose for which it was designed. In this branch of Mining, indeed, many expert Miners are not versed; and therefore it is generally undertaken by persons who have made it their study and employment; who are usually called Binders and Timbermen; and who, according to their reputed excellence, have very great wages; for without a proper application of timber, both the workmen and Mine may be crushed together and destroyed. Of such an event we have had too many instances; but if a Mine that has suffered thus, is worth the charge of recovery, new Shafts may be sunk down from grafs, till they come under the old bottoms, and by leaving over head a firm back or separation, to support and keep up the run of the former workings, it will be again in as good a state as a new Mine.

If only some part of a Mine falls in, or a stull runs; that is, if it breaks down, and fills some of the bottoms with deads; it is usually cleared by shutting of Attal; which is performed by introducing upright Durns, and driving deal boards pointed at one end, between those Durns, and the loose Attal; and at the same time clearing and shoveling away the deads as fast as they can conjunctively proceed with Durns and Laths; by which latter name they call deal boards. By this process they carry a drift of communication through their Attal, to different parts of the Mine.

The great expence in hydraulick machinery that some very deep Mines are chargeable with, very often induces the adventurers to stop their workings for some time, till they bring home a new and deeper Adit. Accordingly they look out for a place to take a level from, that will neither be expensive, nor flow in the driving; and they put more or less force upon the Adit, as they are more or less earnest in the work. When they resolve to be expeditious about it, they are not satisfied with driving one single end, but sink many intermediate Shafts between the lost slovan or tail of the Adit, and the Mine. In this matter, if they do not reflect maturely, and consider, whether they can sink so many Shafts, without drawing much water, they may severely pay for their improvident temerity. The greatest accuracy, skill, and circumspection are necessary in dialing with a compass for an exact and absolute level between  
the



the Shafts and the Adit end. A small error will be of great, very great ill consequence; so that none but sensible, experienced Miners, ought to be trusted with so momentous a transaction.

The new Adit is seldom or never deeper, than the bottoms of the Mine; therefore the holding this deep level to the house of water, is very dangerous. All the former workings, if the Mine has been set idle, must of necessity be filled with water to the level of the first or old Adit. The whole Mine then becomes a house of water, according to the common expression; and supposing they were abruptly to hole the Adit, or make a communication from it to the former workings, without any precaution; then the great weight and pressure of the water, would force its way through so precipitately, that the stream would instantaneously fill the Adit, and the men could not escape drowning. Therefore, whenever they are apprehensive of coming towards a Gunnies, or hollows of a Mine filled with water, they bore a hole with an iron rod towards the water, about a fathom or two, or so many feet, further than they have broke with the pick-axe according to the density, or different texture of the stratum in their Adit end. As they work on, they still keep the hole with the borier before them that they may have timely notice of the bursting forth of the water, and so give it a gradual vent or passage, which will soon enlarge itself, and drain the Mine, when once it begins to pipe out of the borier hole into the Adit. Yet notwithstanding all this care and prudence, they are often in imminent danger of their lives, and are sometimes lost by the sudden eruption of the water. This very hazardous business is generally undertaken by enterprising workmen for the consideration of an advanced price; and I have met with several instances of its being attended with fatal consequences.

In some places, especially where a new Adit is brought home to an old Mine, which has not been wrought in the memory of man, they have unexpectedly holed to the house of water, before they thought themselves near to it, and have instantly perished. Some have driven by the side of the house of water, and have perished also by its unexpected eruption. But I think where they are tolerably acquainted with their situation, much danger may be avoided, by keeping three or five borier holes before them, radiated or displayed above and below, to the right and to the left, from the center of the Adit. This advice  
however



however may not be relished by those who are impatient to be rich, and value a little money more than the lives of their fellow-creatures.

It often happens, however, where they are driving home an Adit upon the course of the Lode, that the water, as they come near the old workings, zighyrs away by flow degrees, through the Adit end, if it is tender and porous; and instead of holeing to the house of water, they very happily hole to Learys, or the old Gunnies, or excavated parts of the Mine.

The new Adit being holed in to the old workings, they immediately prepare to draw out the water; and when the bottoms are forked, or quite unwatered, they proceed to clear them of all slime, fludge, and attal, that may have fallen into them since the Mine was knocked or set idle. Afterwards they sink, stope, and drive in various parts of the Mine, according to the best of their judgment, and in the manner before described. The reader will conceive, that almost every Mine, from variety of circumstances and natural contingencies, will require a different management, and method of working; and that one certain mode for working two different Mines is impracticable. We have only to remark, that no Mine can be well wrought without using the forementioned general methods, however varied they may be in the manner and application.

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A General



A General Display of a Mine, by Notes of Reference to and an Explanation of every Part of a whole Sheet Parallel-Section of Bullen-Garden Copper Mine; wherein is exhibited all the Machinery, and Workings, from Grafs to the Sumph, shewing every Pump, Saller, Ladder, Drift, Stope, End, Winds, and Stull, in the Mine.

1,2 The western water engine tyes, or pumps, which deliver the water to adit.

3 The cistern into which the water runs, from the old fire engine rose pumps 17.

4 A small bore, or small pump.

5 A cistern: the water which comes from Dolcôth Mine through the level 6, runs into this cistern; it then ascends through the small bore 4 into the cistern 3, whence it is drawn to adit by the pump 2.

6,6 An aqueduct or level from Dolcôth Mine.

7,7,7,7,7,7 Poles, or pump rods.

8 Old fire engine tye pumps.

9 The rose cistern.

10 A pump, that conveys the water from the rose cistern 9 to the tye pump.

11 Old fire engine rose pumps.

> Clack door piece, and iron pump or cylinder  
12½ inches diameter.

12 A cistern.

13 Old fire engine crown lift.

> Clack door piece, and iron pump or cylinder  
12½ inches diameter.

14 A cistern.

15 Old fire engine lilly pumps.

16 New fire engine tye pumps.

> Clack door piece, and brass pump or cylinder  
11¼ inches bore or diameter.

17 A cistern.

18 New fire engine rose pumps.

> Clack door piece, and brass cylinder or pump  
11¼ inches bore or diameter.

19 A cistern.

20 New fire engine crown pumps.

> Clack door piece.

21 Cistern.



- 22 New fire engine lilly pumps.
- 23,23 Launder, to convey the water from the rose cistern 9, to the western water engine.
- 24,24 Wooden pumps, to convey the water from the rose cistern 9, to the eastern water engine.
- 25 Eastern water engine great tye pumps.
- 26 Ditto little tye pumps. Both these tyes or lifts draw to adit all the water from the cistern 9, which comes to them through the wooden pumps 24,24.
- 27 A brass cylinder or pump, 11 inches bore.
- 28 Ditto, 10½ inches.
- 29 A cistern.
- 30,30 A shallow level or aqueduct, that conveys the water, after it is discharged from the eastern water engine wheel, to the top of the western water engine wheel, to work that also.
- 31,31 The old level or adit.
- 32,32 The new level or deeper adit.
- 33,34 A level to Dolcôth fire engine shaft.
- 35 Huel-Bryant drift, or a deeper level driving to Dolcôth.
- 36 A drift.
- 37 Kemps end.
- 38 The broad stull.
- 39 The long faller.
- 40 A winds or windlafs, to draw deads, or attal, from the sumph to the stull.
- 41,42 A winds to draw attal from the bottoms to the stulls.
- 43,43 Drifts, driven to the north branch.
- 44,44,44 A stull and way to the top eastern end.
- 45 A drift to south Entral Mine.
- 46,46 Foot-ways and ladders.
- 47 The deep western end, or stool.
- 48 Western bottoms.
- 49 Western shaft bottoms.
- 50 Sumph shaft western bottoms.
- 51 The sumph.
- 52 Sumph shaft eastern bottoms
- 53 South shaft bottoms.
- 54 Tyacks bottoms.
- 55 Eastern bottoms.



# 172 A GENERAL DISPLAY OF A MINE.

- 56 The deep eastern end, or stool.
- 57 A horse in the Lode.
- 48,49,50,51,52,53,54,55 The breadth or bigness of the Lode, in the deep bottoms.
- A,B,C,D,E,F,G,H,I,K,L,M Stopes on the Lode.
- N,N Fire engines.
- O,O,O Whyms.
- P,P Capstans.
- Q,Q Water engine wheels.
- R,R Triangles, rope, and sheaf, for raising the pumps, changing boxes, &c.
- S,S Water engine bobs.

|          |                                                                                                                                                                                    |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 30,30    | A shallow level or aqueduct, that conveys the water, after it is discharged from the eastern water engine wheel, to the top of the western water engine wheel, to work that shaft. |
| 31,31    | The old level or adit.                                                                                                                                                             |
| 32,32    | The new level or deeper adit.                                                                                                                                                      |
| 33,34    | A level to Dolcoath the engine shaft.                                                                                                                                              |
| 35       | Huel Bryant drift, or a deeper level driving to Dolcoath.                                                                                                                          |
| 36       | A drift.                                                                                                                                                                           |
| 37       | Kemps end.                                                                                                                                                                         |
| 38       | The broad shaft.                                                                                                                                                                   |
| 39       | The long faller.                                                                                                                                                                   |
| 40       | A winds or windlass, to draw deads, or attals, from the lump to the shaft.                                                                                                         |
| 41,42    | A winds to draw attal from the bottoms to the shaft.                                                                                                                               |
| 43,43    | Drifts, driven to the north branch.                                                                                                                                                |
| 44,44,44 | A shaft and way to the top eastern end.                                                                                                                                            |
| 45       | A drift to fourth Buntal Mine.                                                                                                                                                     |
| 46,40    | Foot ways and ladders.                                                                                                                                                             |
| 47       | The deep western end, or stool.                                                                                                                                                    |
| 48       | Western bottoms.                                                                                                                                                                   |
| 49       | Western shaft bottoms.                                                                                                                                                             |
| 50       | Sumph shaft western bottoms.                                                                                                                                                       |
|          | The shaft.                                                                                                                                                                         |
| 52       | Sumph shaft eastern bottoms.                                                                                                                                                       |
| 53       | South shaft bottoms.                                                                                                                                                               |
| 54       | Tyacks bottoms.                                                                                                                                                                    |
| 55       | Eastern bottoms.                                                                                                                                                                   |

P. A. H. C.



CHAP. IV.

on Mines, and the Management of them.

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orking Mines, I shall now make those  
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To Francis Bass  
BULLEN GARDEN MIN



172 A GENERAL DISPLAY O

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A,B,C,D,E,F,G,H,I,K,L,M Stopes on

N,N Fire engines.

O.O.O. Whyms.



#### C H A P. IV.

##### General Observations on Mines, and the Management of them.

**H**A V I N G treated, in the preceding chapter, of the manner of working Mines, I shall now make those observations, which are consequent to the working of some Mines, and not of others; and likewise circumstantially explain the arrangement and conduct of the labourers in their several departments.

Mining is so expensive in its operations, and so uncertain in its success, that few or none of our Cornish Mines are carried on at the risk of one or two persons. Where there are so many blanks to one prize, it would be gaming in the extreme, for any person singly to begin a seeking adventure; or indeed, to take up any thing of the kind, which is not already discovered, and likely to be rendered profitable almost to a certainty: and, upon this ground, it generally happens, that the charges of our adventures are borne by many partners, from four to ten, sixteen, twenty-four, and thirty-two. The shares in these adventures, are often so fractional and intricate, that a stranger, though a tolerable arithmetician, would be greatly at a loss to divide and appropriate the Doles or shares, with that precision, which is familiar to many illiterate Tinnners, who can cast a piece of ground, and assign the proportions of a parcel of Copper or Tin Ore, with the utmost accuracy, by the help of twenty shillings, pebbles, or buttons.

The principal manager in the Mine, is the Purser, or Book-keeper; who keeps all the accounts, and receives and pays all the money. This person is usually one of the adventurers; and is chosen by the rest, for the administration of their affairs, during the intervals of their monthly-meetings; at each of which, a state of the transactions and accounts of the Mine is produced, and after it is regularly examined and passed, the total charge is divided according to the Doles or shares, of which each adventurer is obliged to pay his respective quota. The adventurers present at these monthly-meetings take into consideration the most effectual methods of working the Mine; and their determinations, which are settled not by voices but shares, are conclusive for the whole body.



Deep chargeable Mines are carried on by persons of fortune or great skill; but shallow Mines are occupied indifferently either by such, or by the labouring Miners, and frequently by both. When the Book-keepers, or any other officers, by supplying coal, ropes, candles, or other materials, are part adventurers, they are always stiled In-adventurers; and those who live at a distance from the Mine, or have no immediate interest by supplying the works with Materials, are called Out-adventurers. By the Stannary laws, indeed, the latter have the same privilege of supplying a Tin work with men or materials in proportion to their respective Doles; and when this is exercised in opposition to certain In-adventurers, it is productive of much jealousy and contest; so that it is more advantageous to Mines, when they are disinterestedly carried on, and supplied with Materials, by persons who have no property in them. In this case, the bickerings of contending interests are prevented; and the Out-adventurers are satisfied, that too many materials are not crowded upon the Mine by favour and connivance: and yet it is but reasonable, that those adventurers who are in trade, should have the preference in supplying a Mine with Materials, when it can be done with probity and honour.

In large and important Mines, besides the Book-keeper or Cashier, there is a superintendant over all, called the Captain; who having the direction of the works both above and underground, ought to be an experienced practical Miner, and to understand every distinct branch of the business. Under him, are the Bottom-Captains, whose business is to see that the common men perform due labour down in the Mine, and that they do not promiscuously confound the good and bad Ore together, but break them separately, or as nearly so as possible; and also, the Grabs-Captain, who directs the separation of the Ore again above ground, so that the best or most solid parts of it be made fit for sale, especially if it is a Copper Mine, for which reason, some call him the Dresser: but whether as Captain or Dresser, having little more to do, than to direct the repair of what goes amiss in the Bal or Mine, among the horses, whymms, carriers, smiths, carpenters, &c. if he can keep a tolerable journal or day book, he also delivers materials to the men, such as gunpowder, candles, shovels, pick-hilts, &c. and is on that account often called the Material-Man.

Though it is much to be feared that adventurers are often injured by dishonest captains, in conniving at the impositions of  
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the common men ; yet I must declare my opinion, that many private peculations originate from the parsimony of the masters themselves. It is an aphorism in Mining, that “ A Tinner has “ nothing to lose ;” but upon tribute or searching for Tin upon the mere strength of his labour, he puts himself in the way of fortune, to enrich him by one lucky hit. It is said, “ A Tinner is never broke till his neck is broke ;” for though he may lose all his labour this month upon tribute, the next may amply repay all his loss with profit. I, therefore, reckon a Tinner upon tribute, if he can clear thirty shillings monthly, with the chance annexed of gaining four times as much, is better off than a captain at forty shillings without any further chance. There will never be occasions wanting for bad men to decoy servants, and alienate them from their bounden duty to their masters : accordingly, Takers of ground by the fathom in sinking, stopping, or driving, and likewise Takers upon tribute, invite the captains to drink with them, upon free cost, at publick houses ; which leads to a further progress in deceit and corruption, till the incautious captains are seduced from their integrity by the presents of the Takers, whom they suffer to mix and manage the Ores in such manner as will most conduce to their own advantage ; and to measure the ground which is wrought by the fathom, to the loss and injury of the adventurers. Instead, therefore, of allowing the captains to draw the work with their own horses, and to sell the workmen materials and provisions, the adventurers in every Mine of great consequence, ought to give them handsome wages, with a strict prohibition not to have any private intercourse with the Takers.

But, instead of dwelling on the faults of this useful body of men, which are not greater than those of others who are equally destitute of the advantages of Christian instruction and good example, and which the wisdom and generosity of their masters might in a great measure restrain ; we ought rather to consider the number and severity of their distresses, and the most probable means of affording them effectual relief.

The principal part of these arises from the casualties that continually befall them, and require the immediate application of chirurgical aid. It is common for the owners of a Mine to oblige the men to deposit twopence  $\frac{1}{2}$  month with the purser, for the payment of the surgeon belonging to the Bal ; and as all who work less than five stems, and generally all labourers at grafs, are exempted from this contribution, it is levied only upon



upon those who are in constant and imminent danger: and for this sum of two shillings  $\text{per annum}$  from each contributor, the surgeon undertakes to attend at all times however unseasonable, and at all places however distant, and to perform all operations, and furnish all medicines. This kind of contract has subsisted near sixty years; but unfortunately for those unhappy labourers who may hereafter want assistance, the surgeons begin to be weary of it, and are gradually declining a practice, which, useful and important as it is to the sufferers, affords no recompence in any degree adequate to their own skill, labour, and expence. Suppose, for instance, that a Mine employs three hundred men who contribute to the payment of the surgeon; twopence monthly from each, amounts to thirty pounds  $\text{per annum}$ . Now, in the course of a year, it is three hundred to one, that the trepan, or the crooked knife, will be wanted, not only once or twice, but very often; besides the ordinary accidents of burns, wounds, contusions, luxations, or simple and compounded fractures, where the knife is spared; and the blasting one or both eyes, and the two last fingers of the left hand, by gunpowder. An accident of consequence may require at least six weeks daily attendance five or six miles distant from the surgeon's residence; an accident of the like nature may require the same attendance, at the same time, a road five or six miles diametrically opposite: and is there a recompence for all this attention and labour, that is likely to secure the continuance of it?

We wish not that any Mine should be attended by one particular surgeon: we know it is for the advantage of a patient in the progress of his cure, to be under the care of that surgeon to whom his own affection or opinion most inclines him; and when the cure is completed, or the surgeon has done all in his power to effect it, let his bill be discharged by the purser of the Mine, pursuant to stated prices. If this, or some plan like this, is not adopted, the poor labourers must perish very fast for want of necessary help; for to suppose a continuance of the present method, is paying no compliment either to the understanding of our surgeons, or to the compassion and prudence of the Mine adventurers.

But the most effectual relief for all these evils, is a publick hospital. In almost all the large and opulent counties in England, hospitals are erected nearly upon the same plan as those in London: and it is strange, that a county so large as Cornwall,

so



so opulent, and abounding with so many accidents that require the greatest care and expertness in surgery, should be so long without a charity of this kind: I am sorry to observe, it is no proof of the wisdom and generosity of its nobility and gentry.

If the annual proceeds of this county in Tin, Copper, and Fish, are rated only at £400,000, it is generally known, that seven-eighths of that sum are produced from the Mines, by a business the most hazardous under the sun to health and life. As a maritime county, it has a great commercial intercourse with the whole world, by exportation of Tin, Fish, and Oil, and the return of Salt, Hemp, Iron, Timber, &c.: and the conveyance of our Copper Ores coastways, and the return of Coal and Lime, together with our fisheries, and the number of foreign packet boats at Falmouth; keep up no inconsiderable fleet of shipping, and form a valuable nursery of seamen. Surely then, the Mining part of this province must be the most proper and eligible situation for an hospital, for sick and wounded Miners and Sailors. And as Redruth is situated on the narrowest part of the county, is the center of Mining, and within two hours distance from our most frequented sea ports; all these circumstances combine to prove the expediency of erecting a county hospital close by the town of Redruth.

When an accident happens in a Mine, the poor sufferer languishes till the arrival of the surgeon, who is generally sent for in such haste and confusion, that it may happen, he is not provided with every thing proper to administer present relief. I have been called to a person supposed to have a compound fracture of the leg, by a fall twenty fathoms under-ground, and have brought a suitable apparatus; when the case has proved to be a fractured skull, and the leg was only scratched. The patient is then conveyed six or seven miles to his own hut, full of naked children, but destitute of all conveniencies, and almost of all necessaries. The whole, indeed, is a scene of such complicated wretchedness and distress, as words have no power to describe.

How comfortable then, must it be, to such miserable objects of compassion, to be carried to an hospital furnished with every necessary to effect his cure, and every convenience to alleviate his distress! The same trouble which removes him from the Mine to his wretched hovel, brings him to the place built and furnished for his peculiar benefit.



The more I consider this matter, the more I am convinced, the accomplishment of it may be well and certainly effected. A voluntary subscription among the nobility and gentry; the lords, bounders, and Mine adventurers; the Tin and Copper companies; the merchants and owners of fisheries; and every rank and degree of those, who are any ways concerned and connected with the county; would raise a sufficient sum, to build and furnish a large commodious hospital; which, afterwards, may be almost wholly maintained and supported by the monthly contributions of the Miners, sailors, and fishermen. Suppose the whole body of Miners, including all who work at grafs as well as under-ground, men, women, and children, in dressing of Tin and Copper Ores, either in the Bals, or at the stamping mills, were taxed at only threepence a month each: suppose they amounted only to 20,000, and the sailors and fishermen to half that number; the whole would raise an annual income of £4,500, free of all drawbacks, and exclusive of the revenue from legacies, and annual donations and subscriptions. Hoping an object so interesting to the wise and wealthy part of the county will meet with speedy attention and effectual encouragement, I return to our principal subject.

When a Mine is incumbered with much water, it occasions a considerable increase of labour and cost; it then becomes necessary to use all possible dispatch and diligence in working the Mine, and raising the Ore without any interval. When the pick-axe ought to be kept constantly at work, it is usual to work stopes or drift ends by double pick-men; allowing two men to each pick by day, and as many by night, if they work twelve hours core. Those long cores, however, are now generally abolished: when they were customary, they were nothing more than a pretence for idleness; twelve hours being too many for a man to work under-ground without intermission. Accordingly, when a pair of men went under-ground formerly, they made it a rule, to sleep out a candle, before they set about their work; that is, if their place of working was dry, they would lay themselves down and sleep, as long as a whole candle would continue burning; then rise up and work for two or three hours pretty briskly; after that, have a touch-pipe, that is, rest themselves half an hour to smoke a pipe of tobacco; and so play and sleep away half their working time: but Mining being now more deep and expensive than it formerly was, those idle customs are superseded by more labour and industry. Conformable to the humidity or driness of the place,  
the



the density or fairness of the ground, and the distance from the fumph, it may be more or less necessary, to work in cores of six or eight hours with double picks. To work with double pick-men, they allow two men to one pick in this manner: in stoping or driving fair ground, one man works two hours, and then gives the pick to his companion to work with for the same time, and he that stands by rolls or carries off the broken Ore or stuff as there is occasion; and thus they work and carry off alternately. So likewise in boring of rocks for blasting with gunpowder, one man holds the steel borier, whilst the other beats it with a sledge of six pounds weight: the latter having had the hardest task, when the hole is bored to its intended depth, resigns the remainder to the person who had only held the borier, who charges the hole, fires it, and works away the shattered rocks.

After this manner they work out their core till fresh men come under-ground, and relieve them in place: but sometimes they are necessitated to work considerably longer than their stated hours; and then they are said to make a stem, or part of a stem, or to work a stem out of core; for which they are entitled at the month's end to an additional pay for so many stems as each man makes, over and above his stated time of working: but as this is an inlet to many impositions, it ought not to be allowed except upon a great emergency.

A Lode that is large, fair, and rich, will sometimes produce Ore in such quantities, that the men cannot wind it up, and dispose of it, as fast as it is broken; and the want of more plots and room to hold it, greatly retards their operations. In this case, the owners set the winding up of the work so broken, on the Whip; that is to say, over and above the men's stated wages, they give them a small gratuity for every hundred kibbals of Ore that are brought up to grafs out of core: but, in this winding by the whip, a strict attention should be paid to the filling the kibbals to the brim, and also to making a lawful tale of five score to the hundred, for reasons too plain to be mentioned. This method, however, is only pursued in shallow Mines, or at least where Whymms are not erected. Whymms or engines drawn by horses, have larger kibbals; and can discharge more work, not only for that reason, but because they may be kept constantly employed where the quantity of Ore or stuff is very great.

It



It is a good and a customary way for the owners to set their dead ground, either in or out of the Lode, to be sunk, driven, stoped, or cut down, by the fathom: but if there is no choice in respect of saving the Ore clean, or the like, they set it to be sunk, driven, stoped, or cut down upon Tut; and in such case the Miners take what they term a Tut-bargain; that is, a piece or part of unmeasured ground, by the lump, for such price as can be agreed upon, expressing the situation and supposed dimensions of the ground. This is not only beneficial to the owners, but also to the workmen: every one knows, that a labourer employed for daily hire, will not execute that quantum of labour for his master, that he will upon his own risk and account; and, therefore, it is profitable for the Mine owners, to set all their work upon Tut, that can with propriety be so set; and it is likewise an incitement to the industrious Tinner, to acquire additional gain consistent with a good conscience, and his duty to his employers.

Under certain restrictions, it is also many times proper, to set an end to drive, or a shaft to sink, at such a price  $\text{p}$  fathom, for as many as can be driven or sunk for one month; or to drive so many fathoms certain. For instance: I have plain feasible ground in my working shaft, that I am sinking to cut the Lode upon its underlie. I set it to sink by two men in a core of every eight hours; and supposing the men to deserve  $\text{£}3$   $\text{p}$  fathom, I conclude they may sink four fathoms in one month, which will amount to  $\text{£}12$  between six men, for which they find every thing but running tackle. Candles and smith's work deducted, it may be, those workmen may clear for their labour thirty shillings each, which every good labouring Tinner well deserves: but supposing that an alteration of ground may be expected in my favour, I shall then be unwilling to set by the month, and will allow them to sink two fathoms only at that price; whereby I have it in my choice to set for a less price, if the ground becomes more fair after the stipulated fathoms are sunk. In much harder ground, that deserves six pounds  $\text{p}$  fathom, though the same men may sink three fathoms, amounting to  $\text{£}18$ , yet their gain will be no greater than in the former case, on account of their additional cost in smith's work, gunpowder, &c. The same will hold equally true in driving or stoping: but matters of this kind are so complicate and various, that it would be an endless task to explain them all.

When



When they fet a Lode to be broken by the fathom, they are particular in expreffing its fituation and other circumftances, as all fuch tranfactions are or ought to be determined by a publick furvey. Sometimes they fet it by the cubick fathom; for though they muft often break it irregularly, becaufe the Lode may be fmall in fome places than in others, and by means of pillars or arches which they often leave ftanding; yet when the contract is finifhed, they meafure the breadth, length, and depth of each particular place, and adding thefe together, and dividing the amount by two hundred and fixteen, the quotient is fupposed to fhew the number of cubick or folid fathoms, broken by the labourers.

But it is much more usual to set the breaking of the Lode by the square, or superficial fathom ; still remembering the depth that must be broken, as they work along. When the bargain is performed, the captain measures the length and breadth of each particular place ; and adding the particulars into one sum, and dividing that by 36, the quotient gives the contents in square fathoms. If the men are deficient in the depth they were obliged to carry with them, they ought to make it good, before the agreement can be said to be performed. In breaking of solid ground, however, they are generally compelled to carry or work the Lode, &c. by a certain breadth or width, called the Gunnies ; that is a Gunnies of either three, four and a half, or six feet wide ; which are denominated by some, a single Gunnies, a Gunnies and a half, or a double Gunnies wide. A Gunnies is expressive of any certain measure in breadth. Now with respect to the measure of ground so broken, it is more masterly and concise, to take the dimensions in feet and inches, which may be reduced into fathoms by the following plain examples.



Suppose a piece of ground measures as follows : viz.

|         |      |     |   |       |      |     |
|---------|------|-----|---|-------|------|-----|
|         | Feet | In. |   | Fath. | Feet | In. |
| Length  | 27   | 4   | = | 4     | 3    | 4   |
| Depth   | 8    | 9   | = | 1     | 2    | 9   |
|         |      |     |   | Gun.  | Feet | In. |
| Breadth | 4    | 6   | = | 1     | 1    | 6   |

Q. How many are the Fathoms, at three feet to the Gunnies?

### Method of Solution.

[illegible]

Suppose a piece of ground measures as follows: viz.

|         |      |     |   |       |      |     |
|---------|------|-----|---|-------|------|-----|
|         | Feet | In. |   | Fath. | Feet | In. |
| Length  | 19   | 9   | = | 3     | 1    | 9   |
| Depth   | 4    | 4   | = | 0     | 4    | 4   |
|         |      |     |   | Gun.  | Feet | In. |
| Breadth | 5    | 6   | = | 1     | 1    | 6   |

**Q.** How many are the Fathoms, at four feet to the Gunnies?

### Method of Solution.

|               |       |      |     |    |       |           |                   |
|---------------|-------|------|-----|----|-------|-----------|-------------------|
|               | Fath. | Feet | In. |    | Fath. | Feet      | In.               |
|               | 3     | I    | 9   | by | o     | 4         | 4                 |
| $\frac{I}{2}$ | I     | 3    | IO  | 6  |       |           |                   |
| $\frac{I}{3}$ |       | 3    | 3   | 6  |       |           |                   |
| $\frac{I}{3}$ |       | I    | I   | 2  |       |           |                   |
|               | <hr/> |      |     |    |       |           |                   |
|               | 2     | 2    | 3   | 2  | Gun.  | Feet      | In.               |
|               |       |      |     |    | by I  | I         | 6                 |
| $\frac{I}{4}$ |       | 3    | 6   | 9  | 6     |           |                   |
| $\frac{I}{2}$ |       | I    | 9   | 4  | 9     |           |                   |
|               | <hr/> |      |     |    |       |           |                   |
|               | 3     | I    | 7   | 4  | 3     | Fath.     | Feet In.          |
|               |       |      |     |    |       | Content 3 | I 7 $\frac{I}{2}$ |

## Suppose



Suppose a piece of ground measures as follows : viz.

|         | Feet | In. | Fath. | Feet | In. |
|---------|------|-----|-------|------|-----|
| Length  | 13   | 10  | 2     | 1    | 10  |
| Depth   | 9    | 8   | 1     | 3    | 8   |
| Breadth | 8    | 2   | 1     | 2    | 2   |

Q. How many are the Fathoms, at six feet to the Gunnies?

### Method of Solution.

|       |       |      |     |         |      |     |   |
|-------|-------|------|-----|---------|------|-----|---|
|       | Fath. | Feet | In. |         |      |     |   |
| 2     | I     | IO   |     | by      | I    | 3   | 8 |
| I     | O     | II   |     |         |      |     |   |
|       | I     | I    | IO  |         |      |     |   |
|       |       | 4    | 7   |         |      |     |   |
| <hr/> |       |      |     |         |      |     |   |
|       | Gun.  | Feet | In. |         |      |     |   |
| 3     | 4     | 3    | 5   | by      | I    | 2   | 2 |
| I     | I     | 5    | I   | 8       |      |     |   |
|       |       | 7    | 5   | I       | 8    |     |   |
| <hr/> |       |      |     |         |      |     |   |
| 5     | O     | 3    | II  | 9       | 8    |     |   |
|       |       |      |     | Fath.   | Feet | In. |   |
|       |       |      |     | Content | 5    | O   | 4 |

Further, If a plot be nineteen feet ten inches long, eleven feet seven inches broad, and ten feet three inches high, how many solid fathoms are therein, and what is the amount of the charge, at two pounds eighteen shillings and sixpence  $\text{p}$  fathom?

|         | Feet | In. |   | Fath. | Feet | In. |
|---------|------|-----|---|-------|------|-----|
| Length  | 19   | 10  | = | 3     | 1    | 10  |
| Breadth | 11   | 7   | = | 1     | 5    | 7   |
| Height  | 10   | 5   | = | 1     | 4    | 5   |

### Method of Solution.

|                |       |      |     |    |       |      |     |                      |
|----------------|-------|------|-----|----|-------|------|-----|----------------------|
|                | Fath. | Feet | In. |    | Fath. | Feet | In. |                      |
|                | 3     | 1    | 10  | by | 1     | 5    | 7   |                      |
| $\frac{1}{2}$  | 1     | 3    | 11  |    |       |      |     |                      |
| $\frac{1}{4}$  | 1     | 0    | 7   | 4  |       |      |     |                      |
| $\frac{1}{8}$  |       | 1    | 7   | 10 |       |      |     |                      |
| $\frac{1}{16}$ |       |      | 3   | 3  | 8     |      |     |                      |
|                | 6     | 2    | 3   | 5  | 8     | by   | 1   | 4                    |
| $\frac{1}{2}$  | 3     | 1    | 1   | 8  | 10    |      |     |                      |
| $\frac{1}{4}$  | 1     | 0    | 4   | 6  | 11    | 4    |     |                      |
| $\frac{1}{8}$  |       | 2    | 1   | 6  | 3     | 9    | 4   |                      |
| $\frac{1}{16}$ |       |      | 6   | 4  | 6     | 11   | 4   |                      |
|                | 11    | 0    | 5   | 8  | 4     | 0    | 8   | at £2 18 6 p Fathom. |

Amount £32      1      7 $\frac{1}{4}$ .

But



But where there is no respect to breadth, it is usual to call it a superficial or common ground, in stoping particularly. Suppose, for instance, a slope of ground measures sixteen feet nine inches long, and seven feet three inches deep; how many superficial fathoms are therein, and what is the amount at three pounds twelve shillings  $\text{per}$  fathom?

|        | Feet | In. |   | Fath. | Feet | In. |
|--------|------|-----|---|-------|------|-----|
| Length | 16   | 9   | = | 2     | 4    | 9   |
| Depth  | 7    | 3   | = | 1     | 1    | 3   |

Q. How many are the Fathoms?

Method of Solution,

| Fath.           | Feet | In. |    | Fath. | Feet | In.                  |
|-----------------|------|-----|----|-------|------|----------------------|
| 2               | 4    | 9   | by | 1     | 1    | 3                    |
|                 | 2    | 9   |    |       |      |                      |
|                 |      | 8   |    |       |      |                      |
|                 |      | 4   |    |       |      |                      |
|                 |      | 6   |    |       |      |                      |
| <hr/>           |      |     |    |       |      |                      |
| 3               | 2    | 3   | at | £3    | 12   | $\text{per}$ Fathom. |
|                 |      |     |    |       |      |                      |
| Amount £12 3 0. |      |     |    |       |      |                      |

We may with certainty pronounce, there can be no stated rule given for the value of setting ground to break by the fathom; for some may be wrought for four shillings  $\text{per}$  fathom, and other ground may require twenty or thirty pounds.

It may be stoped for 10s. or £4,  
It may be driven for 5s. or £10,  
And sunk for 5s. or £25, and even more  $\text{per}$  fathom.

It may probably answer better in other countries, to set the ground to break on the monthly account or wages, provided the Captain who takes care of it, is a man of integrity and worthy of trust; for the great inconvenience that attends this Tut-work or bargains by the lump, or by the fathom, is, that if the ground proves hard and chargeable in the working, the labourer has no ability to go through with it, and consequently must run from it, and leave it on the adventurers hands. There is then no satisfaction to be had of the Takers of the bargain, because they have not wherewith to make restitution; and, therefore, to obviate this loss, some adventurers insert a proviso in the agreement, that a quarter or some other part of the money shall be reserved, till the bargain is completed, in order to recompense the damage that may ensue on non-performance. Though I have



have seen this forfeiture imposed in several Mines of great importance, I must take the liberty to disapprove of it, for reasons that will plainly shew its insufficiency. A shaft may be set to sink ten fathoms at twenty shillings  $\text{p}$  fathom; and the Takers may be obliged to forfeit one quarter of their earnings, if they run from or desert their bargain. Perhaps the first six fathoms may be sunk for five shillings each; that is, the Takers have so far earned six pounds; but the remainder of the bargain, being four fathoms, may require twelve pounds to finish it, by an alteration to harder ground. Now, in this case, if they desert their bargain, and incur the forfeiture, they are only entitled to four pounds ten shillings; and this they will readily accept of, as they may have earned that money in a few stems; while the adventurers are obliged to reset the shaft to another Pair of men, at the advanced price of three pounds  $\text{p}$  fathom. Hence it may appear to be the interest of the adventurers to set the ground by the lump, or the fathom, when the ground in a shaft or any other part of a Mine is fair and tender, and not when it is hard and chargeable to be wrought; as in one case, the Miners will undertake it at an easy rate, but in the other they will make a large demand, upon a supposition, or at least a pretence, that the ground may still continue hard. But instead of this it would be more easy for the men, and more secure for the owners, to set as many fathoms at a stated price as can be sunk in a month: the men cannot gain great wages, nor suffer great loss: and as ground that is very stiff or dense, requiring ten pounds to sink a fathom, may alter, and be set for a less value, it would be prudent in the adventurers to set but one or two fathoms at that price. These matters, however, from the great interchange of circumstances in different Mines, are too intricate to be discussed in this place; and I wish I may not have incurred the censure of some Captains, for having so far interfered in the cunning workmanship of their order.

The quantity of ground that is broken annually in Cornish Mining, if it could be calculated, would appear incredible. But though it is not in my power to ascertain this matter, yet, for the entertainment of my curious readers, I will attempt to calculate the quantity of metallick Lode broken annually in Cornwall, by the returns of white Tin and fine Copper.

We will suppose the average produce of the county to be three hundred weight of Tin in one hundred sacks of Tin-stuff.

B b b

Allowing



Allowing one sack to weigh one hundred and a quarter, then one hundred sacks will be six tons five hundred weight; consequently there must be one ton of Tin produced out of forty-one tons thirteen hundred weight. The county has been found to produce, annually, for some few years past, about three thousand tons of pure Tin-metal; which multiplied by forty-two tons of Tin-stuff as above, gives the total sum of one hundred and twenty-six thousand tons of Tin-stuff  $\text{per annum}$ .

The Copper Ore sold upon an average for the last ten years, is about twenty-four thousand tons  $\text{per annum}$ , which produce nearly three thousand tons of fine Copper. Now let it be supposed, that two tons of merchantable Ore are produced from every one hundred sacks of one hundred and a quarter each as above: then twenty-four thousand multiplied by six and a quarter, is equal to one hundred and fifty thousand tons of rough Lode. To sum up all, for about six thousand tons of pure Metals, we must dig and dress (the far greatest part by stamping mills) two hundred and seventy-six thousand tons of Lode.

If this quantum of Lode which is worth the charges of dressing, is annually digged and raised from our Tin and Copper Mines, how much greater must that quantity be, which is not alive, but is a dead waste or useless refuse? I will venture to affirm, it may be a portion far greater than the foregoing: but suppose it to be equal, the sum will then be five hundred and fifty-two thousand tons of Lode. Now we all know, the tons of Strata, or country, which are broken every year, must be immense, when we consider the number of Shafts, Winds, Adits, Drifts, Plots, &c. that are continually sinking, driving, and cutting around us. I cannot form a method of calculating this; but if, with the former sum, we make this equal to two millions of tons of Lode and Strata broken annually in our Cornish Mining, I believe my countrymen will not think that I have exceeded the bounds of truth. All this will serve to shew the vast employment for men and cattle in our Mine country; which I am very confident might be much increased, and of course be of more national utility, provided we had a market and a price for our respective Metals; but as the case now stands, we labour under every difficulty and disadvantage that can militate against us, which, as it is now most severely felt by the commonalty of Cornwall, must be hereafter felt by the community in general.

When



When a Mine is in due course of working and produces Ore, the adventurers sometimes find it better to set the Mine on Tribute, than to work it on their own account. The manner of setting or leasing a Mine on Tribute, is this; some able Miner takes the Mine of the adventurers for a determined time, that is, for half a year, a whole year, nay even for seven years, as was the case at Bullen-Garden, and the means of her discovery. If it is a Tin Mine, he articles first to pay the Lord, or the Lord and Bounders if any, their shares or Doles, free of all cost, in the stone made ready for the stamping mill. This must be such a proportion of all Tin-stuff as shall be raised during the limited time. Of the remainder, he pays the adventurers one moiety, or one quarter part, according to the agreement, it being more or less in proportion to the richness of a Mine. For example: In a Tin Mine not bounded, the Lord grants for, perhaps, one-seventh: now the Tin-stuff, when it is properly sized to stones not larger than a man's fist, is divided into seven Doles or piles; the Lord's Agent, Steward, or Toller, casts lots upon these Doles by written tickets, six marked A, and one L, and which ever of them falls to his lot L, on that Dole he puts the turf, and upon the turf a stone. Three and a half of the six A Doles remaining may belong to the Tributor, and the other two and a half to the adventurers, which also is transacted by dividing and casting lots as before. Where a Tin Mine is in wastrel and bounded, the manner of dividing and casting lots, is more complex.

In most Tin bounds, the Lord's part is one-fifteenth of the whole, and the Bounders part is one-twelfth, commonly only one-tenth of the remainder. For instance: The Tin-stuff is divided into fifteen Doles, one of which is marked by the Lord's Agent, as above, after the lots are cast; then fourteen Doles remain, two of which are equally subdivided and carried to the other twelve. One of these, by lot as before, belongs to the Bounders; and that very likely must be subdivided again and again, it being for the most part the property of several persons.

Of the eleven Doles to be divided among the adventurers and the Tributor according to the articles of their agreement, the adventurers shall have three Doles and one quarter of a Dole, and the Tibutor seven Doles and three quarters: they then cast eleven lots, viz. three marked A, seven marked T, and one blank, and where this blank falls, that Dole is redivided into four parts, and lots are recast upon it; one A the adventurers  
part,



part, and three T the Tributors. This, however, is not all; the adventurers three doles and a quarter are again divided into eighths, sixteenths, thirty-seconds, and sixty-fourths, and even much smaller fractions, that each may know and carry away his own.

The Tributor again has several persons concerned with him, who redivide their seven Doles and three quarters in like manner: and thus are these fractional complicated divisions, which at first sight would puzzle the most expert arithmetician, effected by our illiterate Tinnners upon the simplest plan, and with the utmost dexterity, dispatch, and accuracy. To any other but a Cornish reader, it may appear strange, that so much trouble should be taken in dividing and redividing the Tin-stuff in this manner, when it might be carried and returned altogether, and the proportions reckoned in money; but this cannot always be done; for stamping mills are numerous, and the separate estates of several people, whose value rises in proportion to the use and employment they have for them; therefore if the Tin-stuff is rich, every one is ready to carry off his respective Dole or share, immediately after it is divided out, and the lots are cast.

The setting of a Copper Mine upon tribute, has this difference: the Tributor is at the sole expence of digging, raising, and dressing, all the Ore that can be made merchantable; and the proceeds of sales are received by the adventurers, who pay the Lord his one-seventh, one-eighth, or one-tenth part, which ever it is, in money. If it is one-eighth, that is two shillings and sixpence out of every pound or twenty shillings, of the remaining seventeen shillings and sixpence the adventurers may have eight shillings, and account to the Tributor for the residue, which is nine shillings and sixpence: and thus, it is said,  
 “ Petherick Kernick of Hantergantick, Abednego Baraguanath  
 “ of Towednack, Dungey Crowgie of Carnalizzy, and Degory  
 “ Tripeoney of Gumford, have jointly taken a Copper Mine  
 “ upon tribute for nine and sixpence out of the pound.”

When the adventurers thus set a Mine to farm, they oblige the Taker or Tributor to keep the Mine in good repair, and well secured with whatever timber is needful; the putting of which into the Mine, ought to be according to the skill and discretion of a person deputed for that purpose by the adventurers. They also stipulate with the Taker of the Mine upon  
 tribute,



tribute, to work it regularly with a certain number of men ; but not in dippas, holes, and corners, to encumber the adventurers, at their re-entrance into the Mine, with the charge of breaking and clearing the barren part or deads, which the Tributor would otherwise leave under-ground. It is very reasonable that the Tributor should be obliged to deliver up the Mine in good order and condition, at the expiration of the time specified ; and that the adventurers should reserve to themselves and agents, a power of going down into the Mine at will, to examine if the premises be duly complied with and fulfilled.

So far we have been speaking of a whole Mine, taken upon tribute ; but it is much more common, and has been always the case in large Mines, to set several parts of them in small portions of ground called Pitches. A Tribute-Pitch, consists of a few fathoms in length on the course of the Lode : two Pitches may meet half way between two Shafts, and draw their Ore to that Shaft, with which either of them are connected. If a Pitch is high up in the Mine at a shallow level, it is called a Pitch upon the Backs ; but if lower down, in or joining with the bottoms, it is called a Bottom-Pitch. The time they contract for is generally four months, and to work the Pitch at all working times, in a regular manner with a certain number of men. The Tributor is obliged to work one month, or forfeit to the owners twenty shillings for every man he is obliged to employ ; in lieu thereof, if he does not chuse to continue at the month's end, he declines the occupation of his Pitch, and forfeits to the adventurers all the Ore which shall be broken.

The boxes and clacks or valves of the engine pump often go amiss, and if they are not made of good leather well sewed, a misfortune of that nature will happen almost every day ; so that every method must be contrived, to have assistance at hand to man the capstan, while a clack or a box is changing. Accordingly, a Tribute-Taker, as well as every other Miner in a Bal, obliges himself and partners to lend a hand gratis at the capstan whenever required, upon the penalty of two shillings and sixpence for each person respectively who refuses his assistance. Without a regulation of this kind, a Mine would be in danger of setting idle, for want of necessary help : but when they cleanse a boiler, which is once a month ; or drop pumps, that is, let them down into the Mine ; the adventurers charge each man at the capstan a stem or a day's hire, and give them some additional



additional recompence if the weather is severe, or they make a long day's work.

The Takers of Tribute-Pitches in a Copper Mine, are likewise obliged to mix their Ores with those of other Pitches, or with the owners Ores; and to sample the same according to the will and discretion of the Captains; else the parcels of Ore would be very small, where they may be twenty Pitches upon tribute in one Mine. Before the parcels are mixed together, they take from each a fair honest sample, and mark them A, B, and so on, which they call private samples. The assay-master, who buys at the publick ticketing or sale a mixed parcel of Ore, hath these private samples given to him, which he assays for two shillings and sixpence each with all the judgment and dexterity he is capable of, to make the most of each; and it is a very rare thing for any complaint or dissatisfaction to arise from the appropriate dispensations of our assayists, so expert are they in their business.

The use of private samples is this: though the sundry parcels of Ore which are mixed together for sale, may appear nearly of one value at sight, yet it must necessarily follow, that some difference will arise from different management in the dressing and other accidental causes. In a mixed parcel of fifty tons, A may have twenty of fifteen pounds value  $\text{£}$  ton; B may have twenty-five of fourteen pounds ten shillings; and C may have five of sixteen pounds  $\text{£}$  ton, according to the private samples; yet the gross fifty tons may sell for fifteen pounds five shillings  $\text{£}$  ton. Nevertheless the amount must be divided among the Tributors according to the selling price, subject to a regulation by the private samples; that is, the excess or diminution, for what it sells, must be proportioned by the produce of the private samples; for, if fifty tons sell at fifteen pounds five shillings, the amount is equal to seven hundred and sixty-two pounds ten shillings. Pursuant to the above private samples

|                     |   |        |
|---------------------|---|--------|
| A's 20 tons at 15 — | = | 300 —  |
| B's 25 — 14 10      | = | 362 10 |
| C's 5 — 16 —        | = | 80 —   |

The amount 742 10  
which is 20 short by the private samples.

This is called  $\text{£}$ 20 increase by 762 10 which it sold for.

Now



# MINES, AND THEIR MANAGEMENT. 191

Now the method of proportioning this twenty pounds increase, is done by the rule of three direct, thus :

|           |    |        |        |             |
|-----------|----|--------|--------|-------------|
| £.        | £. | £.     | £.     | £.          |
| If 742 10 | 20 | 300 —  | A 8 1  | 7½ increase |
| If 742 10 | 20 | 362 10 | B 9 15 | 4 increase  |
| If 742 10 | 20 | 80 —   | C 2 3  | 0½ increase |

742 10 add 20 0 0  
Amount £762 10.

Here it is evident, that if the Adventurers were to account to the Tributors at the private prices, they would deprive them of twenty pounds of which they ought to have their respective proportions, it being the absolute value for which the commodity was sold. Also, by mixing these three parcels, they have altogether brought a better price by twenty pounds, than if they had been sold separately.

The interchange of terms in this matter is very applicable, and easy to be reconciled ; for in case of a decrease, that is, if the selling price had been seven hundred and sixty-two pounds ten shillings, and the private samples had exceeded that by twenty pounds, making the whole seven hundred and eighty-two pounds ten shillings, then the method of solution would be the same by the rule of three, deducting each ones particular share, according to the amount of his Ore.

We may further illustrate this matter, by entry of an account of Ores, sold and proportioned to the Lord, Adventurers, and Tributors.

Dolcôth Copper Ores weighed the 24th of March 1777.

| Quantity  | Price<br>£ Ton | To whom sold         | Amount | Lord's pt.<br>1-seventh | Adventur.<br>net part |
|-----------|----------------|----------------------|--------|-------------------------|-----------------------|
| Tons £ Q. | £.             |                      | £.     | £.                      | £.                    |
| 21 10 2   | 10 —           | Cornish Copper Comp. | 215 —  | 30 14 3                 | 184 5 9               |

Tributor's Account of the above Ores.

| Quantity  | Price | Amount            | Increase | Amount   | Tributors<br>Part | Tributors<br>Money |
|-----------|-------|-------------------|----------|----------|-------------------|--------------------|
| Tons £ Q. | £.    | £.                | £.       | £.       | £.                | £.                 |
| A 10 10 2 | 11 —  | 115 10            | 3 6 4    | 118 16 4 | 5 from 20         | 29 14 1            |
| B 11 — —  | 8 10  | 93 10             | 2 13 8   | 96 3 8   | 10 — 20           | 48 1 10            |
| 21 10 2   |       | Sold at £10 £ Ton |          | £215     |                   |                    |

By



By this time, I presume, the reader has a pretty clear conception of the affair, and that each share of the £215 stands thus :

|                              |         |     |    |    |        |
|------------------------------|---------|-----|----|----|--------|
| The Lord's one-seventh       | -       | £30 | 14 | 3  | } £215 |
| The Tributors                | - - - - | 77  | 15 | 11 |        |
| And the Adventurers net part |         | 106 | 9  | 10 |        |

The spirit of adventure hath many times so prevailed among the lower people, that very large sums have been won and lost by this kind of gaming, much to the injury of the cashiers, who can have no recompence from poverty and rags. It is a method that will always answer for the adventurers, provided the Takers upon tribute will execute their part and fulfil their articles of agreement, which it is difficult for the adventurers to compel them to perform. These reasons have induced the adventurers in some Mines, to set their Tin and Copper Ore to break by the fathom ; and I believe it is productive of more certain wages to the men, and larger quantity of Ore to the owners ; which is of considerable importance to a Mine, obliged to support a monthly charge of eighteen hundred or two thousand pounds. It would be well if the Takers of Pitches on tribute, would allow so much in their calculations for the decay of a Lode ; for it is generally known those people commonly take a rich bunch of Tin or Copper Ore upon tribute according to its full value in sight, not considering, perhaps, that it is almost impossible for such to be richer ; and that it is great odds whether it may continue half so rich for the limited time. This want of precaution plunges them into many difficulties, when an alteration of the Lode happens from riches to poverty : and, indeed, any person may conclude, that little more than common wages can be gained, by working a Pitch for twelvecence in the pound. Nevertheless, I have known several wrought at that value ; and many score tons of Copper Ore raised out of North-Downs Mine at tenpence, for which a shaft in that Mine bears the name of Tenpenny-Shaft (see North-Downs plate). But my readers will wonder more when I declare, that I have known several hundred tons of Copper Ore wrought and dressed for fivepence halfpenny in the pound, at Huel-Virgin Mine : this, however, must be understood to have been the case, when the commodity brought a better price by thirty ~~per~~ cent. than it now bears : which observation suits with the decreased value of Tin as well or more so ; for it is equally true, that where I have been formerly concerned, as part owner of a Tin Mine, we have set a Pitch to be wrought for



for three fixty-fourths of the whole, or three-eighths of one-eighth in the stone, before it was made merchantable, by the additional expence of carriage, stamping, and dressing.

With respect to the plan laid down by Miners for calculating the charge, at which they can work this or that Pitch, it is much the same as that for stoping of ground by the fathom. For instance: if a Tin Lode is a three feet Gunnies wide, a fathom in depth and length of that bigness will produce fifty kibbals of Lode, which when spaled may amount to one hundred sacks of Tin-stuff fit for the stamping mill. This, when dressed, shall produce three hundred weight of white Tin, which they call "being worth three hundred weight of Tin a hundred;" that is, for every hundred sacks of Tin-stuff, it will yield three hundred weight of Tin-metal, worth, we will say, three pounds & hundred weight, that is, nine pounds. The Tin in the leavings of which (a term that will be more easily comprehended, by turning to the chapter upon dressing of Tin) at five shillings & hundred weight, or more commonly expressed "at fifty shillings & thousand" or half ton, is fifteen shillings. The Lord's part, dues, or land-dole, is one-fifteenth of the whole, that is to say, six two-thirds sacks; the Bounder's or toll part is one-tenth of the remainder nine one-third sacks—these sixteen sacks being taken from the hundred, the residue becomes eighty-four; worth, at the above calculation, seven pounds eleven shillings and threepence, and the leavings at fifty shillings & thousand twelve shillings and fourpence—in all for eighty-four sacks eight pounds three shillings and seven pence.

|                                                                                                                                                 |   |   |   |   |
|-------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|---|
| Now the charge of working the fathom, is                                                                                                        | £ | 1 | 6 | 0 |
| Raising, spaling, and dividing                                                                                                                  | 0 | 8 | 0 |   |
| Filling the sacks and loading the horses                                                                                                        | 0 | 2 | 0 |   |
| Carriage, stamping, and dressing (the expence of which is different as the Mine is more or less distant from the mill) we will allow to be only | 0 | 9 | 0 |   |
| Carriage to smelting-house and expence                                                                                                          | 0 | 4 | 0 |   |

---

In all 2 9 0

So that the Tributor must have two Doles and three quarters out of nine Doles, to get wages; which two Doles and three quarters are worth two pounds nine shillings, according to the above calculation.

D d d

Again,







Again, supposing the Lode to be six inches big or wide, the Gunnies must be two feet big, and one fathom in length and depth of the Lode, to make a ton of Copper Ore worth twelve pounds.

|                                              |       |    |   |
|----------------------------------------------|-------|----|---|
| The expence of digging the fathom            | £1    | 7  | 0 |
| Drawing the broken stuff thirty-four kibbals | 0     | 5  | 0 |
| Dressing the Ore at threepence in the pound  | 0     | 3  | 0 |
|                                              | <hr/> |    |   |
| In all                                       | 1     | 15 | 0 |

Which being divided by twelve, the quotient will be two shillings and eleven pence, the money the Tributor ought to have in the pound to earn a living.

#### C H A P. V.

Of Damps in Mines, and of Levelling and Dialling Mines, Adits, &c.

**I**N a treatise on the wholesomeness and unwholesomeness of air, Mr. Boyle makes it appear, that they depend principally on the impregnation received from subterraneous effluvia, a cause generally overlooked; and it is probable, that most of the diseases which physicians call new, are caused by subterraneous steams. In general, though the wholesomeness of the air in some places may arise chiefly from the salubrious expirations of subterraneous bodies, yet is the air depraved in far more places than it is improved, by being impregnated with Mineral emissions. Indeed among the Minerals known to us, there are many more noxious than wholesome; and the power of the former to do mischief, is more efficacious than of the latter to do good, as we may guess by the small benefit men receive in point of health by the effluvia of any Mineral or other known Fossil, in comparison of the great and sudden damage that is often done by the fumes of Mundick, Arsenick, Vitriol, Sulphur, and other deleterious Minerals. (Boyle, Boerhaave). And though these Minerals are mostly found in Mines, pits, and other places deep under-ground, yet they are commonly scattered on the banks of those Mines at the surface, in all places productive of Minerals as our county is.

Hence



Hence it may, perhaps, be no difficult matter to shew, that an alteration of the common air by an unctuous vapour of the vitriolick kind, raised by an unseasonable warmth, and too great a proportion of watery and other grosser particles mixed with it, may be the cause of those epidemick diseases, which are usually called Nervous and Malignant, Bilious and Putrid.

The Mineral effluvium then, acting on the fluids in a degree short of extinguishing life, is absorbed into the habit, infects the blood, and from that minute the whole frame becomes more and more feeble: whence it will be easy to deduce all the symptoms which accompany a slow continual nervous fever. (Huxham).

It is well known, that this contagion in the blood and animal spirits will produce in different persons very different disorders, though they may justly be attributed to one and the same cause; nay, in the same constitution, by length of time, and the solution of the red blood globules, a slow nervous fever will terminate in the highly putrid and malignant: yet the latter may be immediately derived from the same spring, and shall vary only in a vigorous constitution with rich blood, or in a weak lax habit and very incompact crassamentum. Upon the whole, then, it is not strange that those different disorders are frequently confounded, as the same constitution of the atmosphere contributes to both.

I was drawn into the particular consideration of these matters, by our endemick fevers in the spring of the year 1773, and my peculiar lot to fall in with those of the worst kinds: so prevalent were they indeed, that I may venture to affirm out of three thousand inhabitants here, not less than half the number were manifestly affected in a greater or less degree with febrile symptoms of the nervous, bilious, or malignant kind; and though not above fourteen persons died, yet we have many who may lament the effects of those disorders to the latest day of their lives. In the year 1752, nervous and malignant fevers were reckoned mortal in this parish, and particularly in families where a similarity of constitution equally favoured the production of one disorder. I then knew three brothers to have died of a putrid malignant fever, out of four which had the disease; yet these men all lived in separate houses, at a quarter of a mile's distance; and had the least intercourse with each other that ever I observed in persons so nearly allied: I take this to be



be a great instance of the efficacy of contagion in one derivative habit of body. Some part of our Mining district is ever molested by such violent fevers: one or other of the parishes of St. Agnes, Kenwyn, Kea, Redruth, Gwenap, Stithyans, Wendron, Sithney, Breage, Crowan, Gwinear, Camborne, and Illugan, have epidemick fevers always among them.

Mineral exhalations are allowed to be one cause of contagion, and, Mr. Boyle says, even of the plague itself: my principal design, therefore, is to prove the obnoxious situation of our Mine country to those dangerous diseases; and from thence to infer, that they are with us the peculiar production of Mineral effluvia. If this is not the case, I should like to be informed what occasions those disorders to rage with such violence among us, and be endemial to our Mining parishes? Perhaps it may be said, they are produced by the unwholesome and uncleanly manner of living among the Tinnerns. But I have known them to originate in the most cleanly healthy families; nay, it is notorious, that the more regular livers, and more delicate inhabitants of this town, have more generally and powerfully experienced their attacks.

In December 1772, particularly at the time of the poll for a knight of the shire, we had a warm moist atmosphere for three weeks, without rain, or a currency of air sufficient to blow out a lighted candle. Soon after, nervous and malignant fevers were very rife, and were generated I apprehend by those Mineral effluvia, which, in that month, by means of the foregoing constitution of the atmosphere, were suspended for a considerable time, and particularly affected those persons whose nervous system was very weak and lax, or those of quick and lively sensations; while such as were athletick, robust, and sanguine, generally escaped their pestilential influence. Again; it was observable, that the weather, in December 1774, and in the beginning of January following, was unseasonably warm, serene, and mild; the air for three weeks before was scarcely agitated by one breeze, but continued, all that time, warm, moist, and vapid. The writer then predicted the consequential malignant effects which happened soon after; and he thinks any one may foretel the eventual incidents that must follow such continual unseasonable weather, in a country teeming with Metals and Minerals. But it is time to come nearer to the point in hand, and to shew, that we are obnoxious to poisonous Damps underground, notwithstanding the preconceived notion of many to



the contrary. If it is possible for the superficial Mineral steams of our earth to be thus destructive among us, how much reason have we to conclude, that many instantaneous deaths from Damps in the Mines, are more eminently occasioned by suspended mineralick vapours of the most deleterious miasm.

In those Mines which are replete with Mundick and Copper, and where some parts are not supplied with a sufficient current of air to disperse the effluvia, I have known several men and boys perish in a few months: and though some may linger for a longer time, they are generally grieved with nauseas and reachings to vomit, oppression upon the breast, lassitude and torpor of the limbs, till at last the whole habit becomes tabid, and they die hectic or consumptive.

It is a mistake, that "Damps in our Cornish Mines are never so venomous as to be immediately fatal." I have known many instances to the contrary; particularly one, in a short Drift, by the side of an Adit, which carries a large stream of water, a father and son, with other persons, were walking through the Adit, when the son stepped into this old short Drift, and instantly fell down dead: the father on observing this, followed the son to give him succour, and shared the same fate: their companions seeing this misfortune, avoided the danger, and cautiously recovered the bodies for interment. To what less cause can we attribute this sudden destruction, than to a venomous damp in this particular place; which the famous Grotta dè Cani, so named from its mortiferous effects upon dogs and other animals, cannot exceed?

Mr. Jessop, in the Philosophical Transactions, observes, that there are four sorts of Damps: the first is the ordinary sort; the signs of its approach are the candles burning orbicularly, the flames lessening by degrees, till they quite go out; and shortness of breath: such as escape swooning, receive no great harm thereby; but those that swoon away, and escape an absolute suffocation, are, upon their first recovery, tormented with violent convulsions: the ordinary remedy is to dig a hole in the earth, and lay them on their bellies, with their mouths in it; if that fails, they supply them with large quantities of good ale; and if that miscarries, their case is concluded desperate.

The second sort of Damps is called the Pease Blossom Damp, because it is said to smell like that bloom: it always happens in  
the



the summer time ; and is observed in Mines, that are not infected with any other. It is not reckoned mortal ; but on account thereof, many Mines lie idle for the best and most profitable season of the year, when the subterraneous waters are lowest.

The third is the most extraordinary, and most pestilential of all ; and those who pretend to have seen it, for it is visible, describe it thus : In the highest part of the roof or backs of large Drifts, which branch out from the Mine or main workings, something round is often seen hanging, about the bigness of a football, covered with a skin of the thickness and colour of a cobweb. This, they say, if broken by any accident, immediately disperses itself, and suffocates all the company : therefore, to prevent its ill effects, as soon as it is observed, by the help of a stick and long rope, they break it at a distance ; after which, the place is well purified by fire, before they venture in again. It is asserted, that the steam, arising from the bodies of the Miners, and from the candles, ascends into the highest part of the Drifts, condenses there, and in time contracts a film, which at length corrupting, it becomes pestilential.

The fourth is that vapour, which, touched by a candle, presently takes fire, giving a report like a gun, and producing the effects of lightning.

These pernicious Damps in Mines, shew abundantly, that nature affords inflammable air in some cases ; and we find by experiments, that art can do the same, and that, probably, on the same principles ; for if you mix Iron filings, oil of vitriol, and water, by the addition of common air it will become inflammable. Sir James Lowther having collected the air of some Damps in bladders, preserved it so well, that when brought up to London, it would take fire at the flame of a candle, on letting it out at the orifice of a piece of tobacco pipe. It is well known to all that are versed in chymical experiments, that most Metals emit a great quantity of sulphureous vapours, during the effervescence they undergo in the time of their solutions in their respective menstruums : this vapour being received into bladders, in the same manner with the natural air of Sir James Lowther, has been found to take fire, in the like manner, on being let out in a small stream, and answered all the phenomena of the natural kind.

We



We shall observe that this inflammable air, the condensed air N<sup>o</sup> 3, and the Pease Blossom Damp, are never known in our Cornish Mines ; but that the fixable air which is readily imitated by a mixture of oil of vitriol, water, and chalk, and extinguishes candles, is common to some parts of them.

Dr. Conner in his Differt. Med. Physf. relates a case of some people digging in a cellar at Paris, for supposed hidden treasure: after a few hours working, the maid going down to call her master, found them all in their digging postures, but dead. The person who managed the spade, and his attendant who shovelled off the earth, were both on foot, and seemingly intent on their several offices: the wife of one of them, as if weary, was sitting on the side of a hopper, and leaning her head on her arm; and a boy, with his breeches down, was evacuating on the edge of the pit, his eyes fixed on the ground: all of them, in short, in their natural postures and actions, with open eyes, and mouths that seemed yet to breathe, but stiff as statues, and cold as clay.

I have known some instances in Cornwall similar to this; and I presume it has been often the case with us, that people have fallen into a pleasing kind of slumber, from which they never awoke: at least I have been told so, by some who had experienced the approaches of it upon themselves, and had the fortitude to shake off that fatal reverie, into which they had been insensibly drawn. In the Mine of North-Downs, a drift end was in driving, where the air was scarcely known to be scanty: one evening, at the usual hour of relief, an elderly man, called Bamfield, and a boy, came to the Mine, and went down to their place, from whence the other workmen were just come. Some time after the next hour of relief was elapsed, their partners were surprised that Bamfield and the boy did not come above ground. After waiting a little longer, they went down, and found the boy in a recumbent posture; and Bamfield close to the end, sitting stiff upon his breech, with both hands to his forehead, and his elbows resting on his knees, in a kind of sleepy nodding attitude; but both of them cold and stiff.

A want of air is indeed so frequent, that few of our Shafts or Adits can be driven or sunk to any considerable depth or length, without some degree of its ill effects; but as soon as they can conveniently give the Shaft or Adit a free communication of  
air,



air, they are relieved, and the Damp ceases. For this purpose, they sometimes make use of a kind of air pipe, which conveys air down to the labourers: at other times, they sink a side Shaft; and as they go deeper in it, they work holes or drifts, as occasion serves, from the side Shaft into that which contains the Damp; and this communication between the two Shafts, gives the air a draft or current. But when this want of air happens at the end of an Adit, as it is very usual, they use those methods of fallering, &c. already described, book iii. chap. 3. which supplies them with air till a new Shaft is sunk down upon the end, and holed to the Adit, which gives the men a free respiration, and liberty of working, till another Shaft is requisite. Sometimes they are annoyed with Damps in dry shallow pits, which are probably caused by noxious thick vapours that are emitted out of the pores of the earth; at other times, the Damps seem to proceed from the corrupt effluvia of stagnating waters, that have lain a long time in the Lode or a Shaft. Both these Damps are so thick and heavy, that they kill and subdue the vivifying spirit of the air; so that for want of a fresh supply, the Miners cannot continue long under-ground.

Besides the sinking of Shafts and putting down air pipes or the like, there are some other things which help to set the bad air in motion, and so serve in part to dispel the gross unwholesome vapours: thus, the drawing of water out of a Shaft, and the motion of the tackle, or the water that runs in an Adit, will help to dissipate the bad air; also, if faggots on fire or any burning fuel be thrown into a suffocating Shaft, it will rarify the bad air for a while, and by the admission of fresh air the men may work some time longer, till the Damp condenses and gets to a head again.

Damps are generally most common in summer. About the dog-days we observe they are not so easily remedied by air pipes and fallers, as in the other months; because the earth and atmosphere are greatly warmed by the solar rays, and the air itself is so very calm and serene, that for want of a due agitation thereof, Damps are occasionally more or less, from these circumstances of the season, and very often in those places which are not affected by them at other times of the year. When they blast rocks by gunpowder they are frequently obliged to come above ground, and wait some hours before they can venture down again, to work and clear away the shattered stones. Linden says, he is sure, the smoke of the gunpowder with the

F f f

heat



heat will dissolve and raise up in fumes a great deal of the Terra Mercurialis Metallorum, which will occasion a poisonous Damp; and therefore it is necessary that the gunpowder should be mixed with something that will prevent the solution, and sheath and envelope the acid particles of the salt petre and brimstone. Any unctuous or oily body will do it; and will be so far from being detrimental to the blasting, that it will be rather of service to it, because it will add to the strength of the gunpowder, and make it do more execution than if it was used alone; and not only hinder its smoke from occasioning any noxious Damps, but destroy the naturally poisonous qualities that lodge in the cavities of the Mine. The mixture that I would use with the gunpowder, is as follows:

Take one pound of gunpowder, one ounce of oil of turpentine, two drachms of camphor, and half a drachm of borax. Mix them well in a marble mortar, and they will be fit for immediate use.

Dr. Brown in his Travels and Observations on the Mines of Hungary, a book in which are many excellent remarks on Mines and Minerals, and highly useful to all concerned therein; says, that where an air Shaft cannot be conveniently sunk, the Germans apply a large bellows with pipes of lead or leather to throw in air to the workmen. In the year 1696 this was put in practice, for the first time, in St. George's Adit in Goon-Laz in St. Agnes, where by reason of the great depth, (at least forty fathoms from grafs) it was impossible to sink a Shaft, and to have succeeded without this or some other invention to convey air. It has been since tried in other places with the like success, as I am informed, for I never saw it put in practice myself; indeed it was invented by the lord St. Albans, before the time of Brown's travels, and practised in Wales by his servant Thomas Busshet, Esq; (Fuller's Worthies in Wales, p. 4).

Now as we see some Adits must have a great many Shafts to convey air to the workmen, as well as to save the expence and trouble of rolling the broken work a great way back to the last shaft; so it is necessary likewise for them to understand the use of a dial compass, to direct them where to put down such Shafts as are wanted in their right places. Dialling is requisite in almost every Shaft they sink on an Adit, or else they may dig out of the way to no purpose; and when they work out of their right way in an Adit, it corrects and rectifies their mistake.

Indeed,



Indeed, without Dialling, they would often insensibly go astray from the line they had just begun or proceeded in, and instead of working forwards towards the Mine, they may inadvertently drive in a contrary direction. It is true, a candle is a great guide to the labourers; for if they work so straight as to see a lighted candle that is placed where they began, they need fear no error, in case they began right; but if they once chance to work awry, and lose sight of the candle, it is no longer of any service for keeping them in a straight line.

This art of Dialling is also very useful, in directing them where to sink a Shaft exactly on any part or end in a Mine; and where to sink a Shaft for cutting the Lode, or Gunnies upon the underlie, which Shaft in such case is called an underlier. It is equally necessary in other respects for measuring the ground to the extent of this or that place or limit; for want of which knowledge, one set or party of adventurers may injure another, by encroaching on their property. Hence I apprehend, that Dialling, well and truly understood, is of no little consequence to the different neighbouring Lords and Bounders; otherwise it would be no difficult matter, for the adventurers to drive and dig promiscuously, into the several lands and properties of distinct and separate persons, whereby great confusion and loss might ensue to some or other of them; which this art effectually prevents, by ascertaining the just limits of each, and fixing their proper boundaries, through means of a line hung perpendicularly under-ground, with more exactness than is commonly settled by hedges, ditches, stones, or land-marks above-ground. Nothing can be more exact than a limitation of property, by the breadth of a single line; and yet I really believe a difference of one inch, in some very rich Mines, might make a difference of several pounds to the different proprietors.

This laying out a traverse or measure under-ground, cannot, however, be very accurate with those, who take no account of the points or angles of the compass, but in lieu thereof, chalk the bearing of the line they measure with, on the board the compass lies in; for if they are not exceedingly careful and precise in their operations, they may commit almost unpardonable and irretrievable blunders: yet formerly, before penmanship and figures were so generally understood and practised among the common Tinnners, as they are at present, most of our Mines and Adits were dialled for in this manner.

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The instruments used for Dialling are, a compass without a gnomon or style, but a center pin projecting from the middle of the compass to loop a line to, or stick a candle upon, fixed in a box exactly true and level with its surface, about six, eight, or nine inches square, nicely glazed with strong white glass, and a cover suitable to it hung square and level with the upper part of the instrument: a twenty-four inch gauge or two feet rule, and a string or small cord with a plummet at the end of it: a little stool, to place the dial horizontally: and pegs and pins of wood, a piece of chalk, and pen, ink, and paper.

The method of Dialling an Adit, in order to sink a new Shaft down-right upon its end, is this: first they drop a line or plummet down in their last Shaft, in the middle of the breadth of the Adit; a man that stands at the mouth of the Shaft above-ground, marks the place of the line there on a deal board flung across the Shaft, while the person who dials under-ground observes the spot on which the plummet falls in the Adit; there he holds the end of a small cord in his hand, while another person carries the other part with him, as far as he can go in a straight line, without losing sight of the Dialler's candle: the cord being drawn straight and tight, he holds it in the midst of the breadth of the Adit, while the Dialler fixes the side of the compass accurately parallel with the line, and notes the bearing of the compass upon paper; and measuring the length of the cord to the other man's hand, he notes the length thereof on paper likewise. In the same manner the Dialler takes his second measurement or draft, by setting his line and compass afresh, and proceeding as before, till he comes to the middle breadth of the Adit-end. This being done, he comes up from under-ground, observes the place of the plummet line above at the Shaft, where he sets his compass, and lays off the very same traverse at grass which he took underneath; at the end of which, a new Shaft must be put down, directly on the Adit-end. In case there are one, two, or many more angles or turns in the Adit, the compass must be reset at each of them, and their bearings or lengths measured, and taken down on paper; which will exactly answer to an experimental Dialler, by laying out the same traverse above-ground, as hinted before.

Some, instead of measuring each draft or length of cord, untwist it, and fasten pins of wood numbered 1, 2, 3, and so on, at the noted places, which may serve the purpose; but I think



think it more regular to take the bearings of the compass on paper; and also the respective lengths, in columns opposite each other. It is also to be remembered, that if the cord be wet in measuring under-ground, it ought to be the same in measuring at grass, and vice versa; otherwise it may cause no small error, because when wet it shrinks, and lengthens when dry.

To know the exact depth of an underlying Shaft, and a Winds, and how far a Gunnies may extend from the bottom of the Shaft to the brace of the Winds; you must order some one to descend into the Shaft: then let your string down in the manner of a plumb, through a hole made in a deal board, laid across the brace of the windlafs, taking the most convenient place where it will go deepest, and not touch the sides of the Shaft. Where it touches at the bottom or underlying wall of the Shaft, there let a mark be made with a pick-axe. As the string hangs in the Shaft, apply the side of your dial to it, as horizontally and directly across the Gunnies or excavated Lode (which is here in the Shaft, or the Shaft in the Lode, which you please) as you possibly can, observing what degree the needle stands on, which we will suppose to be fifty-two. This degree you must keep for your square. Then take up the string and measure it by the two feet rule, noting the length of the string on paper in rules and inches, under the word depth, as you are desired to observe in the following example. You may suppose this depth to measure twenty-four rules, which you must set down, and the degree fifty-two directly against it.

Then go down to the bottom of the Shaft, where the mark was made. From hence you may begin to take the underlie of the Shaft, by laying a line horizontally across the Shaft from the mark, to the opposite side, roof, or hanging wall, of the Gunnies or excavated Lode; applying your dial to the side of the line, or moving them up and down together, till you see the needle stand upon your square degree fifty-two. Then drop your line and plummet from the roof or hanging wall of the Shaft, till they touch the side or bottom wall, as you did before from the brace of the Shaft; and where the plummet touches at the bottom wall of the Shaft, make another mark. You must then measure the breadth of the Shaft from the bottom of the last plumb, to the opposite or hanging wall, which we will suppose to be one rule twenty inches. Pull up the line, and measure its length from the rule to the mark below. This measure must be noted under the word depth; because, it is

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the second dropping or plumbing of the Shaft; and we will call it sixteen rules. This being noted under Depth, fifty-two under Degree, and one rule two inches under the word Length, as in the following example; you must descend to the place where the last mark was made, and lay the line horizontally across the Shaft from the mark to the opposite side or wall, applying your dial to the side of the line, moving them up and down together, as you did before, till you see the needle stand upon your degree fifty-two. The line and dial lying thus horizontally by the side of each other, drop your line as far as it will go before the plummet touches the bottom wall of the Shaft, holding the line at the hanging wall where you will see it will go deepest, and not touch the sides. Here make another mark, where the plummet touches; which done, pull up your string, and measure this depth, measuring likewise the breadth of the Shaft where you held it: suppose you say, depth twenty-six rules fourteen inches, degree fifty-two, and length or breadth two rules four inches. (See the example following). Here, the Shaft appears to be eight inches wider than it was, eight fathoms, five feet, and two inches higher up at the bottom of the last drop or plumb; a circumstance very common in all Shafts underlying with the Lode, as in such places the breadth of a Shaft must depend upon the width of the Lode, if it is worth the breaking. But to proceed.

In order to make a third drop in the Shaft, before we arrive to the bottom of it (which I chuse to do, that it may appear in a more practical light, as some Shafts underlie so fast, as to require a great many drafts before the bottom can be dialled, and its position and depth ascertained) we will descend to the mark last made, where the Shaft is two rules four inches, or four feet four inches wide; and stretch a line from the mark horizontally across the Shaft to the opposite wall, applying the side of the dial as before till the needle stands on the degree fifty-two. The line must then be dropped till the plummet touches the bottom of the Shaft, clear from any contact with its sides. Here, at the plummet, a mark must be made also. Observing the breadth of the Shaft at the horizontal line, take up your plumb, and measure how many rules it is; say twenty-eight rules twenty-two inches depth, fifty-two degrees; and the number of inches across the Shaft, say one rule twelve inches, length, or breadth.

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The Shaft being now dialled to the bottom, go down there, and hold the Dial where the mark was made, rectifying the needle to the degree fifty-two. It is many times the case, that a short cross length must be taken, to gain room or liberty to take a long length in a Drift or Gunnies. I will suppose it must be done here; and it is very easy to be done, as before, in taking the breadth of the Shaft, by applying the string or line parallel to the side of the Dial. At the end of the short length, measure how many rules and inches it is, and set it down; which you may suppose here, one rule ten inches; degree fifty-two.

This short cross length being taken, you proceed to take a long length, upon the course of the Lode or Gunnies, towards the brace of your Winds or under-ground Shaft, by giving your assistant the end of the line, and directing him to go back into the Drift or Gunnies as far as he can, till the string touches somewhere on the side of the Drift, yourself holding, at the same time, one end of the line, in the mark you made at the end of the short length. The string must touch no where betwixt you and your assistant. Apply the side of your Dial to the string exactly parallel one with the other: then take the degree the needle stands on (no matter which it is) say thirty-six; and let him that is at the other end of the line drop a stone to the bottom of the Drift. Measure the string in rules and inches, which you may suppose to be twenty-two rules eight inches, degree thirty-six. Proceed onwards to the place where the stone was dropped; and if there is occasion to take another short length or draft, which we will suppose, lay the string across as before, one end being in the mark, rectifying the needle to fifty-two; which being done, set down the degree, and this short draft over against it. Say only ten inches, where you make a mark as before.

This short length being taken, you are now again at liberty to take a long one forwards in the Drift or Gunnies; then let your assistant take the string, and go as far backwards as he can, till the string almost touches somewhere in the middle on the side: thus, (holding one end in the mark you made last, when you took the short length) stretch the line tight, apply the side of the Dial to the string, and take the degree the needle stands on, viz. thirty-six: set down the degree on paper, and bid him make a mark at the end. Measure the line, and note the length directly against the degree (thirty-six) you took last, which



which may be twenty-four rules fourteen inches to the middle of the brace of the Winds.

The next operation is to take the exact depth and underlie of the Winds, which must be performed by rectifying the needle upon degree fifty-two, the old square; but if there be any need to take a short length to gain a greater liberty to plumb the Winds, you must take it. Your assistant descending into the Winds, let the string down after him, and where it touches on the side or underlie, let him make a mark; yourself holding a line or one end of your rule in the mark that was made at the Wind's brace, lay the side of the rule or line parallel to the side of the Dial, and rectify the needle till it stands at degree fifty-two. Note this short length on paper, which you may here suppose to be eight inches. Measure your line; say twenty-eight rules six inches; set it down, and the degree fifty-two also: which being done, go down to the last mark, and because the Winds still underlies, put one end of a line in that mark, and stretch the other horizontally across the Winds to the hanging wall, with the edge of the Dial exactly parallel to its side, and rectify the needle till it stands upon the degree fifty-two. Thus let the plummet down from the hanging wall to the bottom of the Winds, if it will not touch the sides betwixt you and the bottom; set down the length or breadth of the Winds which is two rules, degree fifty-two. Make another mark at the bottom of the Winds where the plummet touched, and measure the depth of this last dropping or plumbing, which you may suppose thirty rules two inches: and thus you have finished the plumbing of your Winds.

If you have any further to dial, observe to take your square degree, where there is this occasion; for if you omit taking your square, you will lose yourself in the exactness of the grounds length, sometimes making it more, and sometimes less than really it is, and so commit very great blunders when you come to dial it above-ground. You must also take care, that you hold your line exactly level, when you take your cross lengths in drifts, and by that means you will have the exact depth. You must likewise observe, that your rule or line lie parallel with the edge of your Dial, that is, equal, at both ends; or else you will miss in taking the true degree. Remember, that under-ground, the Dial is guided by the line; but, above-ground, the line is guided by the Dial. The following example of the foregoing drafts, I trust, will serve to inform



inform the reader, of the manner in which they are noted on paper.

| Depth        |    | Degrees | Length       |    |
|--------------|----|---------|--------------|----|
| Rules—Inches |    |         | Rules—Inches |    |
| 24           | —  | 52      | —            | —  |
| 16           | —  | 52      | 1            | 20 |
| 26           | 14 | 52      | 2            | 4  |
| 28           | 22 | 52      | 1            | 12 |
| —            | —  | 52      | 1            | 10 |
| —            | —  | 36      | 22           | 8  |
| —            | —  | 52      | —            | 10 |
| —            | —  | 36      | 24           | 14 |
| 28           | 6  | 52      | —            | 8  |
| 30           | 2  | 52      | 2            | —  |

Here you see the depth is one hundred and fifty-three rules, one foot, eight inches. The rule containing two feet, make in all three hundred and seven feet, and eight inches, for the depth of the Shaft and Winds; which, by reduction, make fifty-one fathoms, one foot, eight inches, for the true depth of the Mine at that place.

If you chuse to know how much your Shaft and Winds underlie, you must add together the lengths that stand against your square degree fifty-two; in all seven rules, sixty-four inches, which, by reduction, make three fathoms, one foot, four inches, the exact underlie of your Shaft and Winds.

To know the length you have driven in the Mine, without laying it forth above, you must add up the rules and inches that stand under the word length, against your bye degree (thirty-six) which in this example are only two drafts, viz. forty-six rules, twenty-two inches, equal to fifteen fathoms, three feet, ten inches, which you have driven in the Mine.

But if you design to dial and lay it out above-ground, set the Dial upon the degree fifty-two; and looking in your notes for one rule twenty inches, which was the first length, put one end of the rule to the hole in the deal board (page ) slung across the Shaft-brace, where you held the string, when you began to plumb the Shaft. The rule lying to the side of the Dial, and

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the needle being rectified to the degree fifty-two, make a mark at one rule twenty inches upon the ground ; and thus you have done the first degree. In like manner you may do all the rest, if you go over these degrees singly, one by one ; but as here are several square degrees (fifty-two) before you come to any bye one, which goes upon the course of the Lode, you may take all these square degrees together, first adding their lengths together, to know how many inches and rules they are.

The lengths opposite the second, third, fourth, and fifth degrees (fifty-two) are equal to three rules forty-six inches, which by reduction amount to two fathoms, one foot, ten inches, the exact underlie of your Shaft ; therefore if you first measure out so much of your string or line, and the needle is rectified to fifty-two, bid your assistant make a mark there : thus you take all the four degrees together and find the mark at grafs, which he made at the bottom of the Shaft. Go to the mark your assistant made, and look to your notes for your next length, measuring out so much upon your cord, viz. twenty-two rules eight inches ; then let him go forward with one end, and cause some one to hold the other end in the mark he made last : look to your notes for your degree over against that length, which is thirty-six, and rectify your needle to it ; let him that has the plummet end of the line, bring the string to the side of the Dial, yourself standing at some distance from him that holds the other end in the mark. The string lying exactly even with the side of the Dial, and the needle standing upon the bye degree thirty-six, bid him make a mark at the end of the plummet, and so you have done that length.

Now go to your last mark, and put one end of your rule to it, and set the needle upon fifty-two, laying the edge of the rule parallel to the side of the Dial. This length being but ten inches, make a mark there.

Look into your notes for your next length, which is twenty-four rules fourteen inches : measure this out, and let your assistant go on with the string, causing the other end to be held in the last mark. Set the needle upon thirty-six, the degree opposite that length ; apply the line exactly parallel to the side of the Dial and stretch it tight. At the plummet end of the string make a mark, which finishes another length. Lastly, because the other two lengths are both to be taken upon one degree, and there being no other bye degree between them,  
you



you may add the lengths together, and take them at once, which are two rules and eight inches, the needle standing upon the degree fifty-two. The end hereof is the place at grafs, directly over the mark you made at the bottom of the Winds. Here, if there is a necessity for it, or it is worth your trouble and expence, you may sink a new Shaft down-right upon the bottom of the Winds, which you may as infallibly depend upon performing, as on any the most facile transaction in Mining. No one thing is more commonly done; it being often of the last importance to sink down a new Shaft, and thereby save the charge of drawing the work by a double draft. It is not always requisite to sink a new Shaft, directly on the Winds; but whenever it is thought so, the undertakers must first dial underground and afterwards at grafs, before they can presume to sink a perpendicular Shaft upon the Winds bottom.

Now, to know whether you have dialled this exactly or not, without going over it again, add all your square short lengths opposite the degree fifty-two together: the sum will be nine rules, sixteen inches; which, by reduction, make three fathoms, one foot, four inches, the exact declination or underlie of your Lode in the Shaft and Winds, from the brace of the former to the bottom of the latter at fifty-one fathoms, one foot, eight inches, the depth of the Mine or Lode in that place. Again, if you chuse to ascertain the average underlie of the Lode, for one fathom with the other, you must work the above drafts by the rule of three direct; by which it will appear, that for every fathom the Lode has been wrought in perpendicular depth, its inclination or underlie is four inches and a half. This underlie is very small and scarcely merits the name in Cornwall, where frequently our Lodes underlie a fathom in a fathom, and seldom less than two feet in a fathom. Indeed, some few Lodes go down in form of a Zig-Zag; and by that means, at a great depth, deviate from a perpendicular very little from the place where they first begin to sink: but this is very rare; and though it may save cost in not sinking many underliers and winds, yet the conveniency is over ballanced by having a less quantity of Mineral in a given perpendicular Lode, than in that which underlies one half in the other. That is, a Lode that underlies three feet to the right or left from a perpendicular, will measure nine feet in depth for every six of a central tendency.

But to proceed: in laying out the drafts upon the surface, you must next add up the lengths you took upon the course or  
run



run of the Lode, which were but two; viz. twenty-two rules, eight inches, and twenty-four rules, fourteen inches, in all, forty-six rules and twenty-two inches; which, by reduction, are equal to fifteen fathoms, three feet, ten inches: measure these out with your rule and line, and give your plummet to the assistant, to go on with the supposed run of the Lode, causing some one to hold the other end at the board upon the Shaft brace, where you first began to plumb: then go to the middle of the string, and setting the needle upon the degree thirty-six, apply the line exactly parallel to the side of the Dial, and bid the assistant make a mark at the end: go to this end or mark, and measure out your square lengths, which in all are three fathoms, one foot, four inches: then give your assistant the end, holding the other end in the mark; set the needle upon fifty-two, and bid him apply the line exactly parallel with the box, and make his mark. If this mark hit that you made, when you dialled it before, you have done the work exactly; otherwise, you have committed some blunder, and ought to try it over again: for this rule always holds true when you take square lengths, and your lengths forward, on the course of the Lode or any way, by one degree; as you here took thirty-six for your degree.

Many more examples in Dialling might be given, such as, to dial Shafts and Winds that underlie and beat into the end; to dial in a Gunnies with many cross drifts and turnings, and afterwards to square the same at grafs, &c.: but as they are already given in Houghton's Rara Avis, and Hardy's Miner's Guide, and as one hour's conversation with practical Miners will illustrate the subject better than a week's reading, I shall conclude what I have said on it, with this single remark, that the crude, gossany, ferruginous Ores in the Mines, have no influence on the needle of the compass: I have often found, that even the magnet or loadstone will not attract pure Iron Ore (much less the ferruginous Ores of other Metals) till they have undergone the fire, by a calcining heat, or some other process; otherwise, there could be no possibility of Dialling most Copper Mines, because they commonly abound with much Iron (Gossan) in Copper Ores.

The other branch of Dialling, is properly stiled Levelling; which is an operation to find the inequality, ascent, and descent, of any ground or hill. Hence it is of great use for all aqueducts to towns, houses, ponds, mills, &c. and particularly in Mining,  
either



either to bring a water course to a Mine, in order to erect an engine, or else to find how deep an intended adit will be from or to a prefixed or given place. But as the rules of this art are fully laid down in books that treat on land surveying, I need not dwell on it here; especially as the two authors above mentioned have described its use and application to our subject. Neither is it necessary to describe the several instruments and improvements that have from time to time been made and used in Levelling, since the Miners, instead of the true Levelling instruments, called the air level, or spirit level, commonly substitute (though not to their credit, for the best may be had at little expence) a water level of their own construction; which is generally a clumsy instrument in form of a small narrow trough, an inch wide, and three feet long, planed very exact and true.

To find the fall or declination of the ground, they lay this Levelling instrument on the highest part of the ground they are about to level or measure, and by pouring water into the trough, they easily perceive when it lies truly horizontal, and then they proceed in the same manner that is practised by others who use the air level. But when a Mine lies on a steep hill, and there is room for a proper station below for taking a just observation by a quadrant of altitude, then the height of the hill (which is the same as the level or depth of the adit at the Mine) may be easily found by the rules of altimetry. The theory of these operations, however, is not considered by the Miners; neither is a small error discoverable, because they seldom level any great length of ground at one time, and content themselves with the common manual operations.

Dr. Halley suggested a new way of Levelling which is wholly performed by the barometer, in which the mercury is found to be suspended to so much the less height, as the place is further remote from the center of the earth. Hence it follows, that the different height of the mercury in two places gives the difference of level. Mr. Derham found, from some observations at the top and bottom of the monument in London, that the mercury fell one-tenth of an inch at every eighty-two feet of perpendicular ascent, when the mercury was at thirty inches. Dr. Halley allows of one-tenth of an inch for every thirty yards; and considering how accurately barometers are now made, he thinks they are sufficiently exact to take Levels for the conveyance of water, and less liable to errors than the common Levels.



Some years since, the reverend Mr. John Pickering, Mr. R. Phillips, Mr. Waltire a travelling lecturer on philosophy, and myself, took the altitude of the highest eminence of the celebrated Druids hill called Carn Brea, by one of Mr. Waltire's best barometers; when we made the utmost perpendicular height, at the lustration rock basons, three hundred and sixty feet or sixty fathoms from the bottom of Redruth town. Nevertheless, one great obstacle to this way of mensuration in our county, arises from the sudden and frequent changes of our atmosphere, which must influence the mercury, and cause some difference between the spot of departure, and the place of destination, in proportion as the atmosphere alters; so that this method can be used only in clear, serene, and settled weather.



## B O O K IV.

### C H A P. I.

The Method of Sampling and Vanning of Tin-stuff, with the Stamping, Burning or Calcining, and Dressing the same ; with the Manner of Dressing the Leavings, Loobs, &c.

**T**IN-STUFF that lies by the side of the Shaft, when it becomes a great heap, or if it otherwise suits the humour of the concerned, is first spalled or broken to the size of a man's fist or less, by which the most indifferent parts are separated and sorted from the best ; so that perhaps not more than one half of a large heap may be reserved for dividing and stamping. After the Tin-stuff is thus culled, and properly sized, it is divided out in smaller heaps by measure of a handbarrow, that usually contains a sack and a half, or eighteen gallons. These shares, which they term Doles, are parcelled out into so many different heaps on any the most adjacent parts of the field, sometimes to the great prejudice of the husbandman, who is not considered for his damage by the lord of the soil, or the owners of the Mine. The method and number of Doles, into which Tin-stuff is frequently divided, may be seen in book iii. chap. iv. The parcels being laid forth, lots are cast ; and then every parcel has a distinct mark laid on it, with one, two, or three stones ; and sometimes a bit of stick with the initials of the proprietor's name, or a turf laid on the middle of the Dole. When these marks are fixed, the Doles may continue there unmolested for any length of time : the property is settled ; and no one, but the right owner, may add or take from it.

The Doles which are designed for sale, are very accurately measured ; for as the barrows are carried off for their respective divisions, one person, who is the reckoner, keeps an account by making a notch in a stick for every barrow ; and if there be an odd one left, it is equally divided by the gallon, the shovel, and, when it is rich, even by the handful. The Doles being divided, they proceed to cast lots for that which shall be sampled.



fampled. This Dole being turned over, equally levelled and mixed, is then divided by a man with his shovel, into two equal parts, taking a little of the Tin-stuff from one end to the other of each of those parts to the amount of some gallons if the Dole is pretty large. This quantum is bruised down by large sledges to the size of an hazle nut, then equally levelled and divided into four parts, two opposite quarters of which are selected and bruised over again to a smaller size. These reductions and smaller divisions are repeated again and again ad libitum; till the quantity designed for sampling, is well mixed, and made as fine as common sand; when each sampler fills his little canvas bag with it, and proceeds to a trial of its value by water, in the following manner.

To make a rough guess or coarse essay, the sampler takes a handful of it, and washes it on a shovel, till the impure earthy parts are carried off by the water from its sides. The more stony, solid, heavy particles being left behind, they are bruised by an assistant, with a sledge on the shovel, till the whole assumes the appearance of mud. This is washed again, till it loses its muddy aspect; when by a peculiar motion of the shovel not to be described, the metallick particles are collected together on the fore part or point of it. By repeating these bruising, washings, and motions, it becomes clean black Tin, fit for the smelting furnace. This is called a Van (from the French word Avant, foremost, as I apprehend) it being thrown forth upon the point of the shovel, by the dexterity of the sample-trier. After the Tin is thus made clean to his mind, he dries it; and if it be as much black Tin as will entirely cover a good shilling, or rather if it is the weight of a shilling, he terms it a Shilling Van, which is not rich; but if the Van will cover or equal the weight of a crown piece, it is good Tin-stuff, and is termed a Crown Van. Now they say, the Shilling Van will produce one hundred gros or avordupois weight of block or white Tin; and the Crown Van will yield five hundred weight of block Tin, for every hundred sacks in measure, of the respective Doles that the sample or Van is taken from, and so proportionally on, to the richest Tin-stuff called Scove, which is reckoned ten thousand of white Tin-metal  $\varnothing$  every hundred sacks; or in other words, it will produce one hundred hundred weight of Tin-metal, for each hundred sacks of Tin-stuff; yet there is none near so rich as this in any quantity, except a particular stone or lump.

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But a measure of a wine half pint is much more exact and true than a handful, to form a judgment from; though the handful be accounted a half pint. The manœuvre is also more nice and true, by using a large shovel, and taking off the sized Tin from time to time on another shovel, and so proceeding till all the Tin is reduced clean and to a proper size. When this is done, dry the Van in a shovel upon the fire; then take it off and weigh it in a money scales by pennyweights and grains: for every pennyweight and half the Van weighs, the produce will be one hundred weight of black Tin for every hundred sacks of Tin-stuff; and so on in due equation: three pennyweights is equal to two hundred weight; six pennyweights to four hundred weight; twelve pennyweights to eight hundred weight; fifteen pennyweights to ten hundred weight; or, as they term it, a thousand of black Tin a hundred, i. e. for every hundred sacks of Tin-stuff: and if it be Tin worth ten for twenty, or one for two, then the Tin-stuff is valued at five hundred weight of black or white Tin, for every hundred sacks. If the Tin be worth twelve for twenty, the stuff is valued at six hundred weight of white Tin a hundred; or if it be worth only eight for twenty, it is only valued at four hundred weight of white Tin a hundred; and so if the metallick quantity of the Tin be more or less, it must be accounted for after that manner.

This black Tin is rather of a liver colour, though called black in contradistinction from white Tin, or the Metal produced from this black Tin Ore. It is very ponderous; for, in a general way, it may be computed to hold one half clean Metal, and some of it will produce thirteen, nay even fourteen parts in twenty; whence the term of so much white Tin for twenty of black Tin, that is, eight for twenty; ten for twenty, which is the same as one for two; twelve for twenty, and so on, be it more or less given for Metal; in the knowledge of which the sample-triers or Tin-dressers are very expert, without the use of crucible and furnace. Thus if the Van of one hundred sacks of Tin-stuff weighs six pennyweights, being four hundred weight of black Tin at twelve for twenty, the white Tin or Metal must be two hundred weight, one quarter, sixteen pounds.

In the preceding manner, they form a near conjecture of the quantity of white Tin that their work or Doles of Tin-stuff will produce at the smelting-house, when it is dressed, and brought into black Tin. But if the black Tin is infected with any bad brood or mixture, as Mock-lead, Copper, or Mundick, after



the Van is bruised fine and washed, they lay the shovel over the fire, and burn the black Tin, continually stirring it till it smokes no more. Lastly, they wash it again on the shovel, and so the brood is carried off by the water, it becoming light by being burnt; for when black Tin is calcined or burned, it still retains its specifick gravity; but Copper, Lead, and other crude Minerals, become much lighter by torrefaction, and are easily separated from the Tin by water.

It should be observed, that each sack ought to hold twelve gallons of Tin-stuff, though they often hold but nine or ten; which want of measure, when known, should be taken into consideration by the Tin buyer.

Now, whoever intends to buy a quantity of Tin-stuff, either for profit in trade, or merely for the sake of employing his stamping mills, horses, and labourers; when his adventure Tin-stuff falls short, which is very commonly the case, he must not give the value of its full produce, without deducting what is called the returning charges, that is, the carrying, stamping, and dressing thereof. On the other hand, the reader must be apprised, that the value of Tin-stuff, is short of its intrinsick worth by the Van only; for in the dressing and management of Tin by stamping, &c. there are two sorts of black Tin to be obtained, viz. the crop and rough, or the crop and leavings of Tin. The first is the prime Tin, immediately separable from the baser parts by its superior weight and richness; the latter is that which is carried off, and mixed with the lighter earthy parts, by its being under size, and therefore more susceptible of the force and impression of a determinate stream of water. Such Tin being composed of the most slimy moleculæ, as well as of the larger rough grains, which get through the greater sized holes of the stamping-mill grate, have very little Tin in them, and must therefore undergo another treatment to get out and cleanse the Tin. This being called the leavings, must be accounted for and valued in addition to the crop Tin, in proportion to the dense or lax consistence of the Tin-stuff and the specifick granules or minutiae of the Tin Ore in the stone. All this depends upon the experienced judgment of the Tin-dresser; and it is so difficult and various a subject, that a man simply a theorist in the matter, cannot lay down a certain rule on which another can absolutely depend. The customary valuation is, by setting a price upon the leavings of this or that Tin-stuff, according to so much the ten hundred weight or  
thousand



thousand it makes in crop Tin, from fifty shillings to five pounds & thousand for the leavings. Hence it follows, that the leavings of some Tin-stuff will more than pay the returning charges; but whenever the leavings are rich enough to pay those incumbrances, they pronounce such Tin-stuff to be “Tin in the “Bal;” that is, to be worth four, five, or six hundred of white Tin & hundred sacks by the Van, free of all costs and charges, which the leavings will exonerate.

All things being well considered, we may conclude, by trying the sample, how to size a parcel of Tin-stuff by suiting it with a grate or holed plate, adapted to the natural grain of the Tin, which is one of the principal articles in dressing; but of this in its place. Mean while let us observe that the dressings of Tin in its present improved state, has been very lately invented; for by Mr. Carew's account, no longer back than one hundred and eighty years, in queen Elizabeth's reign, the manner of dressing was exceeding slovenly; and I am very sure, notwithstanding our present advance, we are yet at some distance from perfection in that art. He says, “As much almost dooth it “exceede credite, that the Tynne, for and in so small quantitie “digged up with so great toyle, and passing afterwards thorow “the managing of so many hands, e're it come to sale, should “be any way able to acquite the cost; for being once brought “above-ground in the stone, it is first broken in pieces with “hammers; and then carried, either in waynes, or on horses “backs, to a stamping-mill, where three, and in some places “fixe great logges of timber, bounde at the ends with Iron, “and lifted up and downe by a wheele, driven with the “water, doe break it smaller.

“The streame, after it hath forsaken the mill, is made to “fall by certainne degrees, one somewhat distant from another; “upon each of which, at every discent, lyeth a green turfe, “three or four foot square, and one foot thicke. On this the “Tynner layeth a certayne portion of the sandie Tynne, and “with his shovel softly tosseth the same to and fro, that, thro “this stirring, the water which runneth over it, may wash “away the light earth from the Tynne, which of a heavier “substance lyeth fast on the turfe. Having so cleansed one “portion, he setteth the same aside, and beginneth with “another, untill his labour take end with his taske. After it “is thus washed they put the remnant into a wooden dish, “broad, flat, and round, being about two feet over, and “having



“ having two handles fastened at the sides, by which they softly  
 “ shogge the same to and fro in the water between their legges,  
 “ as they set over it, untill whatsoever of the earthie substance  
 “ that was left, be flited away. Some of later time, with a  
 “ sleighter invention, and lighter labour, doe cause certayne  
 “ boyes to stir it up and down with their feete, which worketh  
 “ the same effect: the residue, after this often cleansing, they  
 “ calle Black Tynne. But sithence I gathered sticks to the  
 “ buildinge of this poor nest, Sir Francis Godolphin enter-  
 “ tained a Dutch Mynerall-man, and taking light from his  
 “ experience, but building thereon far more profitable conclu-  
 “ sions of his owne inventions, hath practised a more saving  
 “ way in these matters, and besides, made Tynne with good  
 “ profit of that refuse which Tynners rejected as nothing  
 “ worthe.” Thus far Mr. Carew.

Seeing that a dresser's judgment is required in the choice of a  
 grate, I begin with a description of that first and necessary part  
 of a stamping mill, which is a thin plate of Iron one-tenth of  
 an inch thick, and twelve inches long by ten wide. The mid-  
 dle of this, from eight inches and an half by seven inches, is  
 punched full of holes from the diameter of a small pin, to that  
 of a large reed; for the larger the Tin crystals inclosing the  
 Metal are, so much the more capacious must be the holes, and  
 vice versa. This holed plate, commonly named the Grate (I  
 presume from the custom formerly of discharging their stamped  
 Tin through grates or iron bars) is nailed on the inside of  
 the frame, at Y, plate V, near the bottom where the stamp  
 heads pound the Ore. The Tin-stuff being deposited on the  
 floor, at C, called the Garden of the Pass, from thence it  
 slides by its own weight, the motion of the stamps tackle, and  
 the assistance of a small rill of water, D, into the box at Y;  
 there by the lifters a, b, c, falling on it, after being raised by  
 the axle-tree, d, which is turned round by the water wheel, B,  
 it is pounded or stamped small. The lifters are three to each  
 stamps, made of ash timber, six by seven inches square, and  
 about nine or ten feet long. They are armed at the bottom  
 with large masses of Iron called Stamp-Heads, of one hundred  
 and forty pounds weight in each, or more: these are lifted up,  
 and let fall, between two upright parallel planks of oak timber,  
 by wooden knobs or teeth, called Caps, fixed in the barrel of  
 the axletree at proper distances, and in number proportioned to  
 the circumference of the axis, which goes round by the power  
 of the water wheel. Those caps in their round, take up pieces  
 of



of wood called Tongues, about six inches projecting from each lifter, which are fixed one in every lifter at a proper place, so that each cap from the barrel of the axle comes under the tongues, and lifts them up, one after another, in a uniform rotation. Each lifter with its iron head falling upon the Tin-stuff, bruises it down so small, that it is all discharged through the little holes of the grate. The hinder head lifts first; that falling, forces the Tin-stuff under the second; the second falling, forces it to the third; that falling, forces it on to the small holes in the grate, from whence it is conveyed by the same rill of water before mentioned (which likewise serves to keep the Ore wet, and the stamp heads cool) through a small gutter, e, into the pit, F, where it makes its first pure settlement; for the rough metallick part lies at the head, while the loomy part or slime is carried back by the water, to the hinder part, G. Adjoining to this pit is another large reservoir, H, where the slime leavings coming from the first pit, are finally deposited; the remainder which flows over into the river, being reckoned good for nothing.

When the first pit, F, is full, they throw it up, carefully separating the good from the bad; or in two parts, the head and the tail, according to the discretion of the dresser. Then they carry it to the buddle, I, a pit seven feet long, two and a half wide, and two feet deep. The dresser, or a stout boy, standing in the buddle at I, spreads the pulverized Ore upon an inclined plane at K, called the head or Jagging board of the buddle, by a shovel full at a time, in small ridges parallel to the run of the water, which enters the buddle at L, and falling equally over the cross bar M, washes the lighter parts from the ridges, which are moved to the right and left with a shovel till the water permeating every part separates the better from the worse; the dresser in the mean time lightly scraping his naked foot across the Tin in the body of the buddle, which raises the light waste, in order to its being carried back by the water whilst the Tin remains clean in the head or fore part of the buddle. When the buddle is filled in this manner, if the Tin is of a moderate value it is sorted into three divisions; that next the jagging board, K, at g, is the purest, and called the head or crop, which is saved by itself; the middle, at h, is next in degree, being named the middle head, but more commonly the Crease; and that, at i, being most impure, is by some called the Hind-Crease, which is thrown behind the buddle for leavings, and thence called by some the Tails. If need be, the



head of the buddle is buddled over again, and so is the crease, till it is brought to equal purity with the fore part or head. These buddlings are repeated, till the quantity desired, to a certain standard of purity, is brought about, as they term it, or freed from its waste, which is thrown aside with the tails, and hind-creases, for leavings.

It is then carried to a large vat called a Keeve, about one-third filled with water, where the dresser stirs round the water with a shovel, while another puts in the Tin by a shovel full at a time, letting it fall down into the water by little and little at the side of the keeve, wherein it is continually tozed (tossed) or stirred by the dresser with his shovel, till the keeve is almost filled. By this method the small waste that remains among the Tin swims about in the water. When the tossing is at an end, a boy or two with mallets employ themselves for a quarter of an hour beating the sides of the keeve, near the top (which they call packing) till the whole is settled hard, according to the different gravities of its component parts; when the water is poured off from the surface of the Tin, and the light waste upon it is skimmed off and laid by itself, to be buddled over again by the name of the Skimpings. The Tin is then sifted through a copper bottom sieve, into another keeve of water, by which the gravelly waste, whose ponderosity sunk it equally with the Tin Ore in packing, is separated from the clean Tin; the Tin that runs through the copper or brass bottom sieve, if it does not require to be buddled again, may be made clean by repeatedly tossing and packing it as before. If it is necessary to buddle the Tin over again, after it is sifted (which is the best method for cleansing most sorts of Tin, for there may lie a rough waste, that will not come off by tossing and packing) then buddle it over again, and save it in three parts, viz. the crop, the crease, and the tail. The crop is to be cleansed by tossing, &c. and the crease must be buddled again, out of which must be saved as much as will cleanse by tossing and packing.

The remainder must be cleansed by an operation called Dilleuing, from Dilleugh, to let go, let fly, send away. A dilleugh is a large fine hair sieve, which the dresser holds in a keeve one-third full of water, while an assistant throws a shovel full or two at a time into the dilleugh, which the dresser shakes to and fro, and, by his dexterity, turns round the water in the dilleugh, till all the Tin that is in it is in motion. He then dips one side of the dilleugh under water and raises it again,



again, letting the water run over the other side, either slow or fast according to his judgment of the nature of the Tin and waste: the latter will run or fly over, and is called dilleughing smalls or pit-works; which must be laid aside, to mix with the skimpings, to make the samples of a low value, called the rough (or row) Tin. But there is another operation upon this rough Tin to gain as much out of it as possible, to mix with the crop, which manœuvre they term "drawing the row Tin in the "buddle," viz. by putting the quantity of a small tub full in the bottom of the buddle, on one side forth against its breast; then with a pretty strong rill of water, mostly turned the other side of the buddle, they draw it with a shovel by little and little from one side to the other, where the water runs. By the force of the rill, the roughest and poorest of the row is carried back, while the best stands forth. This must be repeated, till it is cleansed from the rough gravelly parts, which may be known by vanning of it on a shovel: which done, they dilleugh it again, till it is fit to mix with the crop Tin.

The rough that is carried back with the stream, by drawing it over again, may be rendered merchantable at a lower rate than the crop; and the rough of this rough, is thrown aside to make leavings. The pit-works and skimpings must be separately buddled, tossed, and packed again, till they are quite clean, and the residue put by for leavings. Thus every part is kept separate to make it clean; first the head, next the crease, then the skimpings and pit-works, when all are mixed together for the smelting-house, there to be bartered for white Tin, excepting a small proportion of row for an inferior sample, which if mixed with the crop would spoil the whole.

A person that is ignorant of cleansing Tin Ore, may safely undertake to pronounce, whether a batch or parcel of black Tin is well purified or not, by plunging his wet hand into it; for if there is any waste in the Tin it will stick to his hand; otherwise his hand may be drawn without any thing adhering to it, except some few evident Tin grains in the lines of his palm: consequently, if a waste is thus visible in so few points of contact, then certainly must the waste be very great and prejudicial in the whole batch.

From the description of dressing clean work, we must proceed, in course, to give an account of dressing Tin-stuff, that is corrupted with Copper, Lead, Mundick, Black-Jack, and other



other Semi-Metals ; for sometimes we meet with all these sorts of Minerals intimately blended in one and the same stone of Tin Ore ; which being specifically heavier than the Tin, whatever Tin-stuff is incorporated with these must be burnt to evaporate the sulphur, arsenick, &c. after it is first stamped, dressed, and cleansed from its earthy fordes, in the manner before described, in order to make it fit for calcination in the furnace, called a burning-house.

A burning-house much resembles a smelting-furnace, but not in every particular. The furnace is built without doors, at one end of the house, where the chimney is raised to carry off the smoke and sublimate of the calcined Minerals. The house serves no other purpose than that of a covering for the man who rakes the calcining Ores, and the preservation of some few tools that would be unsafe out of doors.

The foundation of the furnace is built of hewn moorstone about four feet and a half high, on which the bed or bottom of the furnace is laid. Under the bottom, a little towards the house where the man stands to rake the Tin, is left a hollow place for holding the Tin after it is burnt, which they call the Oven, that will contain about sixteen or twenty Winchester bushels, with an opening on that side next the stamps plot, in shape and size much like a small chamber chimney, in order to come at and take out the calcined Tin, which is let down through an orifice in the bottom of the furnace adjoining to the house. Except at this orifice, the oven is arched over to lay part of the furnace bottom upon. The top, bottom, and hewns (sides) of the calciner were formerly made of moorstone wrought very fine ; but brick is now mostly used, it being more durable for fire work than stone. The length of the calciner is generally about nine feet, and the width five in the belly or middle, gradually decreasing towards the chimney or house to sixteen inches, and towards the grate or fire place to three feet, which is at the further end directly opposite to the house and chimney. The hewns, or sides, are about ten inches high ; upon which is turned a flat arch or covering, which includes the fire place also. This grate or fire place is about ten inches wide, and three feet long ; at the side of which, between it and the furnace, is a brick thick partition or bridge three inches high, to prevent the Tin from mixing with the coal. Over this bridge the fire constantly reverberates upon the matter in calcination, while the smoke and sulphur ascend the chimney at the house-end



end opposite the fire place. Upon the top of the arch or back of the calciner, is made a square hollow place called a Vate or Dry, sufficient to contain a serving or hand barrow full of Tin, which acquires heat enough to dry it ready for calcination in the furnace below, where it is conveyed through a small hole in the bottom of the vate.

A calciner of these dimensions, will consume three Winchester bushels of coal to every serving, if the Tin is greatly corrupted with a stubborn brood, but most commonly half the quantity, or less, will do; also some sorts of Tin, that are very sulphureous, will yield a flame for several hours, and greatly help their own ignition to the saving of fuel in the operation. As for the time of making a complete calcination of a serving or laying of Tin, it cannot be limited till a trial is made; for if it is not very foul, it may be burnt in six hours, and so on the contrary from that to twenty-four hours, according as it is more or less corrupted; especially if there be Copper in it, when it will require a longer time to weaken and deaden the Copper as they pretend, otherwise it will not cleanse so well in the future dressing; that is to say, the ignition must be strong, uniform, and constant, to render the Copper a light waste to wash off from the Tin, which by the strongest calcination used here, loses very little of its first ponderosity.

When the fire is up, and the first serving of Tin in the vate is dry, the dresser lets it down into the furnace through the hole at bottom, where he levels it with his rake through an opening twelve inches square, made under the chimney in the house. After it is all down, he stops the hole in the vate with clay, and carries another serving into it in readiness for the next layer. The Tin in the calciner must rest for some time before it is turned, that it may be quite hot; otherwise if it be stirred before ignition it will effervesce and fly up the chimney; but when it is ignited, and ready for turning, the dresser rakes it backwards and forwards alternately, moving that which is furthest from the fire near to it, and that which is close by the grate further off. This must be repeated over again, at due intervals of perhaps every hour, or more frequently if the nature of the Tin requires it. But in either case, a strong heat should be kept up, and the fire not let to slacken, till the Tin is fully calcined; which may be known by the dead weight of the Tin against the rake, by its having exchanged its fiery red hot appearance for a black one, and its yielding little or no arsenical smoke upon stirring.

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The Tin after it has been sufficiently burnt is let down into the oven before mentioned, and from thence is drawn out and sifted in a keeve, through the brass or copper bottom sieve; whence it is removed to the buddle, and undergoes all the several lotions of buddling, tossing, packing, &c. till it is quite clean for smelting.

Let us now advert to the dressing of leavings of Tin. Leavings consist of slime and tails; that is, of Tin mud and Tin gravel, which a Lappier, or dresser upon tribute, will commonly undertake to bring about for the master Tinner, for one-third part of the produce to pay his charges; or, in other words, the former will account to the latter, for two-thirds of the produce in white Tin, free and clear of all trouble and expence. The tails I have shewn before are in absolute bulk, produced from the hinder or tail part of the buddles; from whence they derive their name of tails. The slime being compounded of the small and lighter parts of the Ore intimately mixed with a greater quantity of earth and stones, bruised to dust by the mill, is floated on to the slime pit H, which is emptied, as occasion requires, on one side, into another slime pit called a Hutch, till it accumulates to a great heap, where the water leaks away and leaves it dry, exposed to the sun and air, which do not a little contribute to its better working when it comes to be dressed; for this we find every day by experience, that the longer the slime is left before it is dressed, the more profit it yields, and the purer the Tin: from whence some have concluded, that Tin in the state of sludge or slime, by length of time, must grow and increase. It must, however, be confessed, that the sun and air act as menstrea upon the slime, by consuming or rather dissolving the Poder, that is, the Mundick, particles of Copper, and other trash, not so dense and compact as the Tin, which comes out the cleaner and with greater ease by such insolation and exposure. Therefore, when the water is sufficiently soaked out of the slime hutch, it is removed further off to a large plot of ground near the vessels destined for its future lavations, where it is spread and exposed to the weather that it may moulder and decay the faster. Then it is digged and broken to pieces with a bidax, or hedging tool, when it is trunked and framed, thus:

A trunk O, is a pit lined with boards ten feet long, three wide, and nine inches deep. At the higher end is a circular pit Q called the Strék or Strep, large enough to contain four hand



hand barrows full of slime, where it mixes with a little rill of water that floats it down into the semi-circular pit P called the Head or Pednan, wherein a boy treloobs or stirs the slimy water round about with a small shovel, that the water may wash away both the filth and Tin over a cross board ten inches deep at the lower part of the pednan: the board is somewhat lower in the middle than at each end, for admitting the watery mixture with more ease into the body of the trunk O, R, R: that which rests in the fore part of the trunk at O o, is carried off to be framed, and the settlement at R, R, is moved forwards to P, to be trunked over again before it is fit for the frame: the rough grains lie at the bottom of the strék, whence it is removed for stamping, and the most light and small slime passes the bottom or lower end of the trunk into a pit, where it settles and acquires the name of Loobs.

The frame or rack T W, consists of two inclined planes of timber; the body W, the head T. The frame is an oblong square eight feet by five, with sides four inches high, all joined closely, that nothing may escape but at the extremity or lower end. At the middle of the two ends are fixed two round projecting irons called Melliers, by which the frame hangs and turns as it were on an axis, upon two upright pieces of timber one at each end, whereby the frame may be swung up and down, perpendicular to the horizon. The head T, is two boards wide, and in length parallel to the breadth of the frame. To the bottom of this is joined a water head, or board, seven inches high; to which is hung, by hinges, a slight piece of board six inches wide, and the length of the head, called the Lap, or Lippet, whose use is to convey the water and Tin equally down upon the frame. Underneath the fore part of the frame, is fixed a little tray or chest three feet long, called the Kôfer, and another at its lower end called the Hind-Kôfer.

The water falling in a gentle manner from S upon the head T, washes the Ore, which there offers itself (as at the buddle) in little ridges, downwards over the lippet, upon the body of the frame W. On this frame the water is spread so thin, and runs so slowly, (the plane being very little inclined) that by moving the slimy Tin to and fro with a light hand, and exposing it cautiously to the water by a small semi-circular toothless rake, all the fordes are washed away, and the Tin though ever so small, remains on the frame near the head. When the Tin is found sufficiently clean, the body of the frame being hung on  
melliers,



melliers, as I have said before (by flipping the stake underneath, which supports it) is turned easily from horizontal to perpendicular; and the Tin which remains on the frame runs off, by the assistance of a little sprinkling, in two degrees of purity, into the fore and hind kôfers. The frame is then righted into its horizontal position, and the process repeated till the kôfers are full. The smaller slime, which runs off the lower end of the frame, is yet preserved in a pit by the name of Catchers, and makes a part of the loobs or leavings of leavings, to be worked over again at a future time. The contents of the fore kôfer is then sifted through a fine hair sieve or copper bottom, into a keeve with water in it, to separate the gravel, chips, or any other accidental mixture from it. Then it is buddled and saved in different portions, like crop Tin; as well undergoing the several operations of tossing, packing, skimping, dillhuing, &c. After all, if the Tin is very small, it is carried to the frame again, and reframed or cazed, as they term it; which is performed, by stoping the lower end of the frame with mud and turf, that the water may be almost still, and the Tin more easily settle upon the frame, and descend the more surely into the kôfer: the fore kôfer is then emptied the second time, the Tin carried to the keeve again, there tossed, packed, skimmed, &c. and thus the slimes are finished, and brought to as great a degree of purity, as the size of the Tin will permit, which being exceeding small, will necessarily have somewhat more of waste, than what is larger and heavier.

The great pile of tails behind the buddles, are commonly washed down into the trunk below, by a pretty strong current of water, which may be rendered more or less forcible by an alteration of its fall, to divide the rough from the small, by treloobing them in the semi-circular kôfer of the trunk with a shovel. The small that flashes over into the trunk, is designed for framing, and so divided into two parts, the fore, and the hind kôfer. The latter must be tossed and framed again; but if the fore kôfer is pretty good, it may be tossed and packed, the skimpings of which must be cazed in the buddle, that is, one person buddles it as usual, but with a very small flow stream of water, while another with a few quils fixed on the end of a pole, lightly sweeps the buddle across from side to side, beginning at the bottom, and so proceeding forward every stroke, till he comes to the breast of the buddle, when he returns in like manner progressively to the end or tail. By this method it is made fit for cleansing in the keeve, &c. and the hind part, that



that is not fit for tossing, &c. must be framed again, and proceeded with in the former manner.

Mean time, all tails that are taken from the bottom of the trunk head or pednan, together with the roughs (or rows) that come from the slime, or from the tossings of the hind and fore kôfers, that are not of a proper size, must be stamped over again, and dressed in the manner before mentioned for bringing about the crop Tin or bal work. But in the stamping them, care must be taken to suit them with a proper grate and small weight of tackle, or worn old stamp-heads; otherwise they may be stamped under size, and choak the grate, which they call being dumbled; to prevent which, they mix with them a small quantity of Gossan or poor Tin-stuff, to cut and jagg them up, else the stamp-heads would mudify them too much to pass the grate holes as freely as they ought: nay I have known common Quartz used for this purpose, entirely destitute of Tin. If there be a corrupt brood in the leavings Tin, so as to damage its value two parts in twenty, it must be burned in the manner before directed, but with a less violent fire, and then dressed again from its calcined impurities: the calcination of leavings Tin should, however, be always avoided if possible, because it is so fine, like floran Tin, that it will, by its sized levity, be elevated and carried off, together with the arsenick and sulphur.

The modes of dressing Tin and its leavings, are too various to lay before the reader, without danger of prolixity: all of them depend upon the difference of the kinds of Tin in the stone, and must be dealt with, agreeable to the judgment of several manufacturers. So much depends upon the skill of a dresser, that one may save one-twelfth part of a batch of Tin, which another for want of equal knowledge may cast away in waste, or perhaps take up so much waste with it, as to depreciate the value of the whole by two parts in twenty. Nevertheless, all dressers save the hinder stuff from the frame end, as it washes off in a pit by the name of Catchers, which is expressive enough; and likewise the mud at the trunk ends, by the other name of Loobs, both of which are denominated the Loobs, after leavings, or leavings of leavings. These are wrought over in the same manner as the former, mostly upon tribute, by an aged workman and a few little boys in the summer months, when they can stand out in good weather, and do a long day's easy labour. The tribute paid by the undertaker is one-third



of the produce in white Tin ; the other two-thirds he has for himself to pay his cost and charges.

Proceeding upon this single principle, that the force of water, properly applied and introduced among the particles of Tin Ore and the fordes mixed with it, will disperse the latter and leave the former at rest for them to collect and treasure up, they vary their operations inconceivably, conducting them with great ingenuity, lessening, encreasing, diffusing, or contracting their water, the great instrument of purity, as the size, weight, and combinations of the Metal and its feeders require ; and that with great ease, cheapness, and regularity, throughout the several processes.

Hence, this business of dressing is a particular trade, entirely different from that of the labouring Miner ; and is best learned under a master workman, who makes it his sole occupation to follow the stamping mill and the works belonging thereto. This master workman hires boys from seven years old to eighteen, gives the former about three shillings a month, and raises their wages as they advance in years and workmanship, till they have man's wages, viz. at the least twenty-four shillings, at the highest thirty shillings  $\text{per}$  month. This is of double benefit to the poor parents ; and the boys being taken in so young, become healthy and hardy by using themselves to cold, and to work with naked wet feet all day ; and they learn early to contribute to their own maintenance. Each stamping mill which has constant work and water, will employ one man and five boys ; and one hundred sacks are carried, stamped, and dressed, in the space of a few days, at the average rate of about fourpence  $\text{per}$  sack, or one guinea and a half  $\text{per}$  hundred.

We shall here observe, that even burnt leavings of Tin are often considerably valuable, especially if they are cupreous ; and even the poorest of these leavings bring ten or twenty shillings  $\text{per}$  ton ; which is better than to throw them away, as was the case no further back than forty years. All burnt leavings taken from Tin-stuff, till the year 1735, were esteemed good for nothing. But in that year there were several small parcels lying on sundry stamps plots in this parish, which induced Mr. Morgan Bevan, an old experienced assayer, to try whether he could reduce them into Metal. For the first time he assayed a sample of three tons ; and, to his own great surprise, as well as that of others, he found that he could give seven pounds four shillings and



and fixpence  $\text{£}$  ton for them, which he actually did, and presently after bought several parcels more of Messrs. Carter, Reynolds, Penrose, Cornish, &c. the principal Tin dressers of those days. From that time all burnt leavings were taken much care of, provided they were sufficiently impregnated with Copper; for some of them are merely Mundick, with little or no Copper in them. When the Brass-wire Company carried on the great Tin Mine of Chacewater, before this discovery they cast away some hundred tons of burnt leavings, to their great prejudice; but since that time there have been large quantities sold from the same Mine.

The very water in which burnt Tin is washed, may be converted to a useful and profitable account, either by evaporation to a pellicle for crystallization of Copper, commonly called Blue or Roman Vitriol; or for the precipitation of Copper by the medium of Iron, laid in vessels filled with this vitriolick water. The precipitation of Copper by Iron, is too generally understood to make an explanation necessary here; but we have observed among our Copper precipitate, where it has been effected by a very strong solution with the cleanest Iron, several pieces of malleable Copper, some of them retaining the form of the Iron, like incrustations fallen off from it. Hence it seems as if there was a degree of attraction between the Iron and the particles of Copper, floating in the water; as well as the more obvious attraction between the acid and the Iron. Must not the particles of Copper thus attracted, cohere by their own magnetism, or the attraction of cohesion?

It may not be improper to add how far this quality has already tended or may tend to the advantage of the publick. Perhaps the history of its rise and progress in this country, and in Ireland, may serve to illustrate that matter. About sixty years ago, this phenomenon was first observed by Mr. Coster in Chacewater Mine near this town; for after he had drawn out the water, which had been in the Mine for several years, he found the poll of a pick-axe wholly encrusted with a case of malleable Copper between two and three pounds weight. This it was justly supposed was observed by the workmen, some of whom afterwards settled at Cranbaun Mine in the county of Wicklow in Ireland. The water of Cranbaun having this vitriolick acid in a very high degree, Capt. Thomas Butler, who was one of Redruth, and manager of that Mine, persuaded the proprietors to adopt the scheme of precipitating Copper, of which



which they have made for many years past and now continue to make very considerable profit. They dig pits at proper distances in the Adit, (or so near as to admit the water) in which pit they place wooden rails, somewhat like a bottle rack, so as to suspend the Iron thereon. They put in many tons at a time; and, in about six weeks, the Iron is totally dissolved. The precipitated Copper is then taken out, fit for sale; the greatest part in the form of our Goffan pounded, with several grains of pure Copper interspersed.

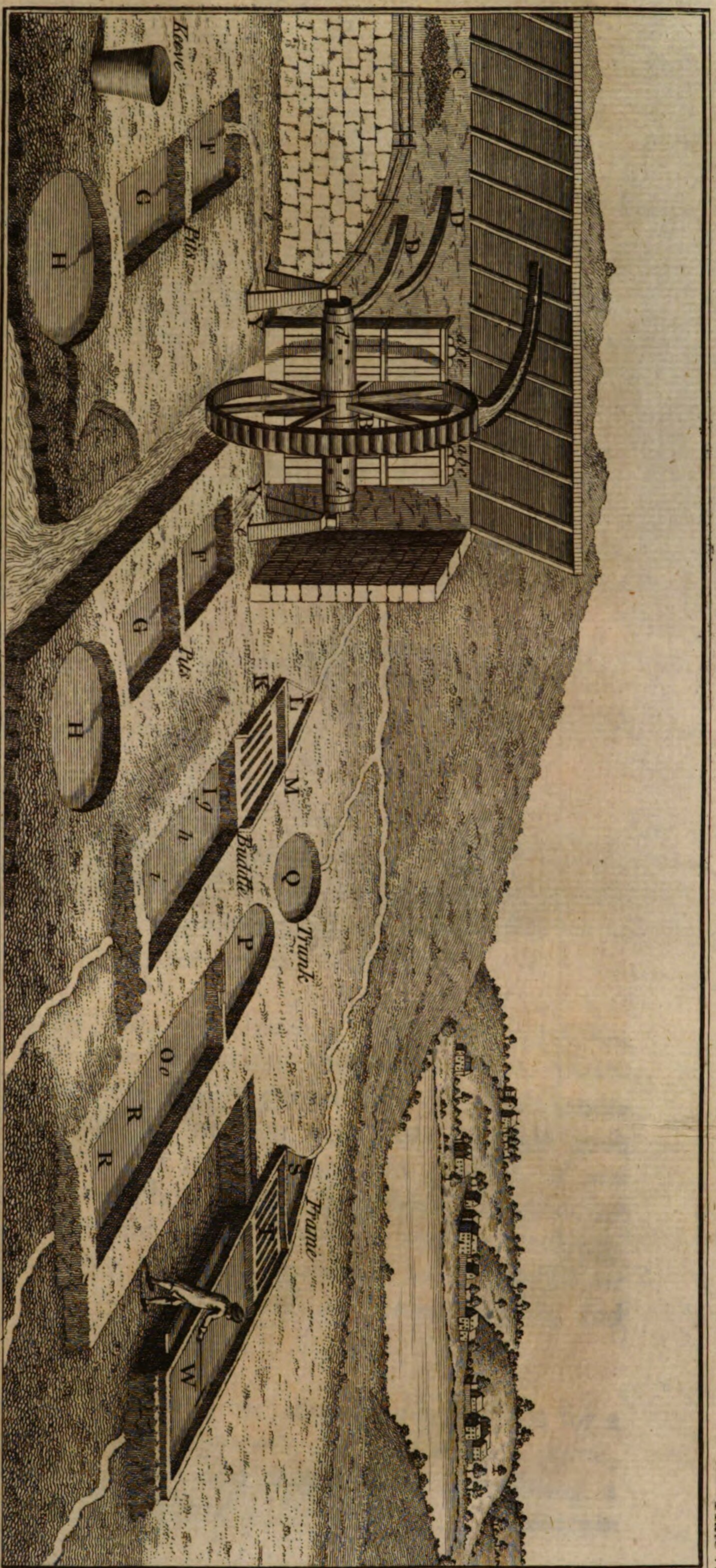
An attempt of this kind was some years past made in Huel-Crafty, but without success; for the water being in one part of the Mine only, and in no greater quantity than would run through a quill, was too much diluted by other water mixing with it in the hutch where the Iron was placed; besides, the Iron itself was very rusty which will always obstruct the success, unless the water is in the highest degree impregnated with the acid. A small and ready experiment proves this; for take a bright piece of Iron, such as a key, or polished knife, and immerse it in the water for half a minute, and it will be stained of a Copper colour. Many Mines in this county have some rills of this water, so as to do considerable mischief, without having as yet (perhaps for want of proper attention) applied it to this use.

But though we may date the first hints relating to this matter in England and Ireland from the foregoing discovery in Chace-water, it is no new thing in other countries. Brown mentions it in his travels into Hungary, as a profitable appendage to the Mining of that country. Dr. Ruty, in his Natural History of Dublin, says, "Our water at Cranbaun in the county of Wicklow, may well vie with those of Herengrund and Ciment in Hungary. Of ours I received the following account in the year 1765 from a person conversant in these matters."

"It is said to transmute Iron into Copper; but the fact is, that it precipitates its contained Copper upon Iron bars immersed. It continues in its full strength; and, in seven years last past, yielded to its proprietors a sum no less than seventeen thousand two hundred and fifty-nine pounds eighteen shillings and ninepence halfpenny, and all this without any expence of fuel and men. The precipitate thus formed being fluxed, yields above half of pure Copper: for an ounce gave twelve pennyweights and eighteen grains in one experiment, and thirteen pennyweights twelve grains in another."

C H A P.





To the Right Hon.<sup>ble</sup> Humphrey. Morice M.P.  
 Lord Warden of the Stannaries and Steward of the Duchy of Cornwall.  
 This Plate Engraved at his Exceience is most gratefully Inscribed by  
 W.<sup>m</sup> Fryce.





*[Faint, illegible handwritten text, likely bleed-through from the reverse side of the page.]*



## CHAP. II.

### Of Dressing Copper and Lead Ores, and Sampling Copper Ores for Sale.

WHOEVER considers the dissimilarity of Copper Lodes, in my chapter "on the different kinds of Lodes in respect of the earth and stones they contain," will soon perceive, that there can be no uniform method for dressing their Ores: the hard and poor Ores require much bruising, and many lotions, before they can be separated clean, and made fit for sale, such as the hard Peach, Quartz, Killas, Mundick, and Black-Jack; but the more tender Peach, Pryan, Crystal, Killas, Mundick, and Flookan Lodes, admit of less handling, less water, and of course are attended with less expence in the dressing, provided they are well given for Ore; for it is one general maxim, that a judicious application of water, the principal separator of them from their fordes, constitutes the first article of skill in dressing Copper Ores.

The manner of dressing and cleansing Copper Ore, is partly like that of Tin; but as good Copper is commonly dug and raised in large masses, as little mixed with any thing else as possible, a great part of it is solid Ore that needs no washing. When it comes to grafs they make a sortment of the larger stones from the smaller, and spal or break them to a less size, throwing aside the poorer part, which is afterwards to be strêked and washed. But when Ore rises plentifully, and with little waste, it may perhaps be a loss and detriment to wash it; and, therefore, if it comes moderately dry, a person near the Shaft where it rises, sifts it in a Griddle, or iron wire sieve, of one inch mesh or less. The part that runs through the griddle, if not clean enough for sale, is washed; and it is seldom that griddled or small Ore is so pure and clean as not to require washing. The poor and smaller Ore is generally carried to the strêke or strakes, sometimes after being griddled, but oftner before, and as it comes out of the Mine.

The strêke or strakes is made of two deal boards laid flat for a bottom fourteen inches in the ground, on an inclined plane, with two sides formed of one deal board each, resembling a

O o o

narrow



narrow shallow chest without a cover. In this runs a pretty quick stream of water. One person throws the foul Ore into the strêke, while another moves and tosses it with a shovel in the stream, by which means the slimy earthy parts are carried by the water into a slime pit just below; and the stony coarse poorer part settles in great measure on the tail or lower end of the boards, which at times is divided, and cast aside to be stamped, as it contains some Ore. The better Ore by its gravity, and a peculiar motion of the shovel in stirring it, rests at the head of the strêke. But if there be much pure Mundick in it, this also settles mostly near to the head of the stream, because it is more ponderous than most sorts of Copper Ore; and it is separated and laid by itself. Moreover, the largest stones, either of Ore or waste, rise uppermost by the motion of the shovel; these the dresser throws on one side of the strêke, where women and children sit to pick out the good stones of Ore, and are from thence called Pickers. The remainder is laid by to be Bucked, or broke smaller with flat iron hammers made for that purpose, if the Ore be worth this trouble; otherwise it is carried to be stamped.

The picked Ore, which is rich and solid, is put to a number of girls called Cobbers, who break it on large stones with flat polled hammers to the size of a chesnut and less, and it is then called Cobbed Ore, being the same as Knocking or Bing Ore in the Lead Mines. This requires no water, nor further dressing, being fit to mix for sale. The stony Ore that is left by the pickers, which is called by some Dredge Ore, from its being poor and sprinkled as it were in the stone, and also the little refuse which is separated by the cobbers, are carried to the bucking-mill, which is something like a wooden coal scuttle placed on a low hedge with a hard stone at its lower narrow end, whereon a strong wench with her flat hammer or bucking iron breaks those stones, to the size of small beans or pease.

From thence it is carried to the kieve or vat, where it is further cleansed by an operation called Jigging; which is by far the best method, not only for those Ores which have undergone a previous lavation, but also for all tender rich Ores, as they are immediately dug out of the Mine.

Preparatory to jigging, they fill the kieve half full of water, on the surface of which the jigger holds a coarse wire sieve of two holes to the inch, while another person throws the unclean  
Ore



Ore into the sieve, which the jigger dips into the water and shakes twice or thrice until the smaller part falls through to the bottom of the kieve. What remains in the sieve, he reserves by itself, till there is a quantity. This coarser size made by the sieve, is jigged pure and clean, if it be well given for Ore; or else it is picked, and the refuse bucked over again, pursuant to its richness or poverty, and the dressers direction and judgment. When the kieve is almost full, they pour off the water, and take out the small Ore, which perhaps they sort again after the same manner in sieves with lesser holes. Being thus divided, they dress each sort apart, in kieves half full of water with proper sieves, whose holes are small enough to keep the Ore from running through.

The jigging sieve made of brass wire four or five holes to each square inch, and sometimes for small Ores seven or eight holes, is held by the jigger in the kieve, while a girl throws two or three shovels full of the Ore into it. The jigger dips and shakes it a few times in the water, by a peculiar indescriptive motion and turning of the hand, which makes the light waste, such as Quartz and Killas-gravel, &c. rise uppermost in the sieve, the Ore lying under it, and the Mundick (if in any quantity) under the Ore, each according to its specific gravity. Now to separate these, the jigger takes a small semi-circular piece of wood called a Limp, being the shape and size of half the head of a quarter hundred powder barrel, with which he scums or rakes off the light refuse or gravelly part, and throws it by, perhaps to be jigged over again. In like manner he scums off the good Ore, and lays it aside for sale. Lastly he reserves the remaining Mundick, until it comes to some quantity, in order to jig it over again; because the first operation may not be sufficient entirely to take out all the Ore, either from that or the light waste that lay uppermost.

This refuse part of the Ore is commonly so light, being as I have just said, a Quartz and Killas-gravel, that it may sometimes be very properly put to the strêke, and washed in a pretty quick stream of water, which will carry the waste to the tail or hinder part of the strêke, so as to be divided from the good Ore, which lies at the head. But the slimy fine Ore, which falls through the fine sieves to the bottom of the kieve, is often cleansed by the tye, which is the same as the strêke, but with an exceeding slow and small stream of water, or, which is much like



like it, by buddling or framing, the same as Tin Ore; also by jigging it in a very fine close sieve like a dilluer.

All this is varied and modified according to the discernment of the dresser: and though Ore cannot be perfectly dressed by water so as to be entirely clean, yet all Ore, except Tin-stuff, is best cleansed by jigging, though it is the slowest way, and of consequence the most costly; also the slimy earthy part is apt to lie among the last or smallest Ore, more than in the other methods of dressing, and thereby depreciate its value: therefore I suppose the fine slimy part of it may be packed in kieves like black Tin; but the dresser's guide in this case, should be the tenderness and value of the Ore. Here is not, however, that waste of Ore, that is made by the strakes, which is the reason why the method of jigging ought to have the preference.

As the foregoing is the most general rule for dressing of Copper Ore that I can form, it would render my dissertation upon the subject too prolix, minutely to describe the various methods of cleansing different sorts of Ore: I shall, therefore, content myself with just hinting the several distinct operations each sort separately requires, and leave the regulation of them to those who are employed in the business.

Common yellow Ore should be separated at the Shaft side, the rough from the small, either by griddle or strêke. The solid Ore should be further disunited from the stony part, by spaling with sledges, or cobbing with hammers to a proper size.

Dredge Ore, which may be left from the above, or which may rise so poor and disseminate in the stone from the Mine, as to deserve that name, in the first place, should be spaled, cobbled, and then bucked to a proper size to run through a sieve two holes to the inch, preparatory to its being jigged in a four or five hole sieve. The remainder should be washed, and then put on a table of loose deal boards, that the pickers may chuse the good from the bad, that the good may be handled as the first. The small, which runs through the four or five hole jigger, should be tyed in a fine small stream of water; and thus by repetition be made fit for sale.

If Copper and Tin Ore are mixed together, which is often the case, the latter being mostly the heaviest body, may be wholly saved in the fore part of the tye, by repeated essays.

But



But if each Ore is of equal gravity, (and I apprehend some poor Tin Ore, which they call dry for Metal, may be less ponderous than Copper Ore) if the tye will not separate them, they should be first cleansed from every other impurity, and then moderately calcined in a burning-house. The Copper Ore being thus rendered light, will easily separate from the Tin, and both will be made saleable by buddle, kieve, dilluer, &c. I am not certain whether all this may be too expensive or not, especially when I recollect that some buyers of Copper Ore may prefer it with some Tin for smelting to pot and bell-metal.

Copper Ore that is charged with Mundick, may be disunited at the strêke or by jigging, provided the Mundick is hard and solid; but if it is small and fine like sand, it must be separated by the tye, buddle, kieve, &c.

If the infection is Black-Jack, care must be taken in cobbing and picking to divide them, as they are nearly of one weight. Some have advised calcination; but they are alike ponderous after calcination; and, therefore, water will equally float them away. Mock-Lead is not the worst brood in Copper Ore, especially for the use of the brass founders, it being a Zinc Ore.

Gray Ores are generally the heaviest of all, and are commonly infected with Iron. They must be dressed like the common Ores, by sorting and sizing them, &c.

In the dressing of light pryany black Copper Ore, very little water is necessary; for the small should be sifted, and put to pile from the Shaft side; and the remainder must be cobbed, bucked, and jigged: but if it is committed to a small stream of water, the major and best part of it will be carried away and lost by its superior levity and fineness.

The prime Ore being separated and dressed by itself, the refuse goes by the names of Halvans and Hennaways; and is generally dressed over again and again by strêke, stamps, &c. The halvans of halvans are mostly dressed by an undertaker for so much in the pound sterling of the money they produce, according to the richness or poverty of the Ore, and the price it will bring when ultimately dressed. No exact estimation can be made of the value of a pile of Ore halvans: the method of calculating, is by guessing how many tons of Ore it will make for every hundred sacks of the pile. As for those halvans,

P p p

whose



whose contents are less than half a ton & hundred sacks, it is scarce worth the trouble of returning and dressing it, except the Ore is rich in quality, and will bring a good price: much also depends in this case upon conveniencies, care, and expence more or less in carriage and water to dress it.

Halvans stamped small, and then washed in a strêke with an easy stream of water, is termed Stamp Ore. But a finer sort is still to be had from the slime pit, which proceeds from the minute particles that glide away with the mud and water; this sort will not bear a brisk stream, therefore it still retains much dirt and mud, whence it is called Slime Ore. The rough part of stamp Ore should be tyed in a stream of water, and the hinder part of the tye jigged through a six or seven hole sieve. If it is much adulterated with Tin, Lead, or Mundick, it must be cleansed by frequently tying or buddling of it. In order to clear the earthy fordes from the slime or loobs, it may be trunked, and after purified by the buddle, kieve, dilluer, &c. the same as slime Tin, if it is worth the expence. It must also be noted, that Copper Ore requires a coarser plate or grate in stamping, than Tin does, because it is of a lighter nature and more fleaky.

I have heard of a poor sandy Copper Ore somewhere in Wales, of the appearance of verdigrease, which is so light, that the cupreous part of it will not bear even the least stream of water: they dress it by grinding, dry stamping, or bucking; then put it into tubs or kieves, and toss and pack it the same as I have observed of Tin: now the real Ore in it being without any sulphur, or much Metal, is specifically lighter than the waste or sand; therefore the Ore swims uppermost, and is skimmed off in the manner of Tin skimpings. But I suppose those extreme light Ores are so very poor, that none would be concerned with them, only in hopes of their improvement.

It is worth notice, that Copper Ore may be too curiously or too remissly dressed, so that either way the adventurers may incur a loss; the ground of which is sometimes not so well considered as it deserves. If too much time and cost are expended in dressing the Ore, every one will grant it infers a loss; but on the other hand, if too much foul Ore is left in it, that will also be to the prejudice of the concerned. Every ton of waste Ore costs as much to be smelted as a ton of clean; at least, the buyer subtracts as much for a ton of the one, as the other.

Suppose



Suppose the buyer allows three pounds sterling for his charges of smelting and working a ton of Ore, and consequently the same sum for each ton of waste in the Ore, which in reality the smelting costs the buyer or refiner; and therefore he must deduct so much from the produce of the Ore  $\text{per ton}$ . This is the case in Cornwall; but in other places, more distant from the furnaces, in Ireland for instance, the deduction must amount to more money, in proportion to the duty there on Ore, and also an overplus of freight, and if there be any other surplussage of cost, more than in Cornwall, as a longer carriage by land, and the like, all will operate to lessen the value of the Ore: but where such incidents are less than common, as a very short freight, or little charge in land carriage, then instead of a deduction, there is room to make a further advance of the price.

To illustrate this case, suppose one hundred tons of Copper Ore, to be worth ten pounds  $\text{per ton}$ , the amount of which will be one thousand pounds; suppose also it has so much earth or waste in it, that it may be reduced to fifty tons, with a moderate charge in dressing, and with an inconsiderable loss of the Ore; then each ton will contain nearly the Copper which two tons did before: and whereas the buyer would have taken out six pounds for the charges of carriage, freight, and smelting of two tons, he will now deduct but three pounds for those charges upon the same Ore in one ton: so that instead of deducting three hundred pounds on the one hundred tons of Ore, he will now deduct but one hundred and fifty pounds on fifty tons, whereby the adventurers will save so much of the other one hundred and fifty pounds, by how much the parcel of Ore will cost less for dressing and taking out the waste; for the fifty tons of Ore will now be worth twenty-three pounds  $\text{per ton}$ , which will amount to eleven hundred and fifty pounds instead of one thousand. Yet if the Ore be light or rich, there may be more of it lost, than the useless waste carried off may compensate.

Again, if one hundred tons of waste were mixed with the one hundred tons of Ore worth ten pounds  $\text{per ton}$ , then the buyer would make an additional abatement of three hundred pounds more for his charges upon the one hundred tons of waste; so that the whole amount of the Ore, would be but seven hundred pounds, instead of one thousand pounds; for the Ore would be only worth three pounds ten shillings  $\text{per ton}$ ; according to which, it is plain, that Ore may be too curiously or too carelessly dressed. For Ore rich in nature, may be brought to  
a great



a great rate, and produce a large profit to the adventurers; otherwise it may be sold to a great disadvantage, and without any gain, for want of being well handled: there are, however, several poor Ores, so dry and barren by nature, that they are not capable of being so well conditioned, as to bring a good price.

The conclusion I would draw from hence, is, that if a ton of waste can be taken out of the Ore, for less than the charge of smelting a ton (which I call three pounds here) and without any considerable loss of Ore, the adventurers save money by dressing it thus: but if the charges of taking out a ton of waste arise to more than three pounds, then they lose as much as the excess of cost amounts to, together with the Ore washed away; hence, mediocrity should always be observed.

The dressers of Copper Ore often work for monthly wages, but then they do not always make the dispatch they ought; therefore they more commonly agree with the adventurers at a certain or fixed price for every ton of dressed Ore; but this makes it the dressers interest, to make the greatest number of tons that he can, so that the adventurers may suffer a loss, for want of a true cleansing the Ore. To prevent this inconvenience, the best method is to set the Ore to dress in proportion to the price it brings  $\pounds$  ton; or in other words, to allow the dresser so much in the pound sterling, according to the price the Ore will bring; for this makes it his interest, as well as the adventurers, to make the Ore as merchantable as he possibly can: however, he should be stinted from throwing away too much Ore in the halvans, or be obliged to stamp the halvans, and return their contents in Ore.

There can be no stated rule given for setting Ores to dress at a price, because the Ore is incompact, or less, as well as poorer in value, in some Mines, more than in others; but where Ore rises with little waste, it may be dressed at a much cheaper rate, especially if it be rich in quality. I have known Copper Ore in several Mines, where it might be sifted out at the Shaft side, without any other trouble, to be dressed for one penny in the pound sterling; on the other hand, five shillings may not be a sufficient price for Ore that is hard and barren.

It may be worth enquiry, whether very sulphureous Ores which abound with Mundick, may not be advanced in value  
by



by a previous uſtion. It is evident from the foregoing obſervations, that if Ores be made conſiderably lighter by being burnt and deprived of their ſulphureous heavy waſte, with a ſmall charge and no loſs of Metal, that then it muſt be an advantage to the owners, by putting the charges of ſmelting the evaporated Mundick into their own pockets. Suppoſing this ſhould answer the end propoſed, the moſt proper time of burning muſt be after the Ore is dreſſed and fully cleaned by water; for if it were done before, the Ore would acquire ſo great a levity and tenderneſs that it muſt unavoidably float away, in a great meaſure, with the water, though but a very ſmall ſtream, and be inevitably loſt and conſumed: it would likewise be ſo much ſmoked and diſcoloured, that it might deceive the dreſſer in judging when it may be right clean. Nevertheless, if a parcel of Ore be dreſſed clean and then burned, a great part of the Mundick muſt evaporate, and the Metal or Ore will remain in the pile; therefore, for every ton of Mundick, that would ſublime from it, the parcel would be worth three pounds more on the entire quantity. For inſtance; if one hundred tons of very pyritous Ore were decreaſed to eighty by this method, the adventurers would ſave ſixty pounds, from the diminution of its weight or loſs of Mundick; as well as gain, by its improved value, as much at leaſt as would pay the charges of burning, which I preſume would be ſmall, for the Ore may be burned in furnaces ſimilar to thoſe commonly uſed for the calcination of liſtſtone; or by kindling piles, conſiſting of ſtrata of fuel and of Ore placed alternately upon one another, and by other pieces of uſeleſs timber, which ſhould reach from top to bottom of the piles. Theſe being burnt out, and the Ore ſettling ſteady, the vacancies of the burnt timber would ſerve as flues or chimneys to carry off the vapours, and keep the fire from being extinguished too ſoon, eſpecially if the ſmall Ore was thrown on after the other Ore was well kindled and thoroughly burning.

Otherwiſe, a ſmall arch or channel of looſe bricks may be placed on the ground, where part of the round Ore may firſt be eaſily kindled by a fire of charcoal or wood; and as the fire increaſes, the place may be fed and ſupplied with more Ore, till the whole pile be ſet on fire; for Ores that are very ſulphureous, are ſo combuſtible, that they ſoon take fire, if well ordered, and will burn a long time, or till they are moſtly deprived of their ſuperfluous ſulphur, when the fire extinguishes of itſelf, for want of a Pabulum or feeder. Fig. 11, plate VI, represents a quantity of Ore piled up to be burned: 1. two ſides

Q q q

or



or faces of the pile : all the sides of it are covered with small Ore : 2. the upper part of the pile where holes are seen, which serve as flues both to help burn and evaporate the Mundick and sulphur : 3. an opening to set fire to the pile, and in which the sulphur may drop pure when melted : 4. a plank to keep off too much wind. Fig. 12, is a section of the above pile : 1. the wood to make the fire : 2. some charcoal for kindling the fire : 3. a channel formed by a wooden tube or pipe to begin a draught of air : 4. large lumps of Ore : 5. small Ore : 6, 7. finer Ore, or dust of Ore.

When the Ore grows cold, it is fit for smelting, but must by no means be any more cleansed in a stream of water. By this management it will run much freer in the great furnaces for such a gentle deprivation of its stubborn brood of sulphur and arsenick ; and I am pretty clear will also yield more Metal, than when it is melted crude in the furnaces, where the sulphur and arsenick being excited by a violent fire, may elevate or carry off some part of the Metal in their passage. The worst inconvenience that seems to attend this matter, is, that it requires to be done near the Mine, to prevent the charge of removing the Ore ; in which case, the smoke being blown by the wind, would be offensive to the workmen, without a due precaution to prevent it. To my astonishment, neither this method nor any thing similar to it, takes in Cornwall, though it has been used with success in Germany, it seems even before the Ore is washed clean ; and therefore it may much more reasonably be thought to turn to account, after the Ore is cleansed.

Indeed, the adventurers of Bullen-Garden Mine, some few years past, not only calcined their poor Copper Ore, but smelted it likewise into a regulus, and that at an expence which was very easy to be borne for the improvement of the Ore in its value : but this attempt was of no long duration, the Copper Ore buyers very honestly confirming the suspicions of the adventurers, that they did not, neither would they offer at so high a standard for Copper Regule as they would for Copper Ore, because an encouragement of this kind, would necessarily deprive the trade of some part of the labour, which was very profitable to them. That argument, backed by a more powerful one, viz. not giving half value for Regule, obliged the adventurers to decline a very useful and profitable business and employ for this country. For my part, I think the gentlemen concerned, should have advanced their undertaking, in proportion to the backwardness



backwardness of the Copper companies, by erecting more furnaces, and running the same Regule into fine Copper; a circumstance of great notoriety, which might be followed by many good consequences for them and their neighbourhood.

Lead Ore, like that of Copper, as it comes out of the Mine, is very little of it merchantable, or fit for sale or smelting; the fossils and soil mixed with it, must first be separated by breaking and washing, according to the nature, richness, or poverty of the Ore.

As for Lead Ore that does not rise very solid, it ought to be bucked and jigged, and very seldom carried to the strêke, or stamps, except it be very scarce and thin in the stone; but when it is so poor as to make bucking and jigging improper and costly, then it is scarce worth the trouble of stamping and dressing: however, when it is so treated, the grate of the stamping-mill should be yet coarser than for Copper Ore; because Lead Ore breaks into Facets or flakes, and is thence liable to float away and be lost, even with a very easy stream of water. The method of jigging has been used a long time in the Lead Mines in Cornwall, though but very lately in the Copper Mines, and they find it to turn to good account both in the one and the other. There can be no doubt, that the Cornish were almost entirely obliged to the Derbyshire and other Lead Miners, for the best method of dressing Copper Ores in the first place; which I suggest from the antiquity of Lead Mines in the northern counties, and the much later discovery of Copper Ore in Cornwall: to which we must add, that the great similarity in the nature and gravity of Copper and Lead Ores, would naturally incline us to use one and the same method for their purification. Nevertheless, it must be allowed, that the great varieties of Copper Ores in Cornwall, some of which require a very nice management in dressing, have given her Miners a preeminent judgment in that matter, which is warranted by continual observation and experience.

But when Lead Ore rises rich, in large solid pieces, it is broke with a hammer into cubes, from half an inch to one inch of a side; and this is called Bing in Derbyshire, but in Cornwall it is stiled Cobbed Ore. Such part of the Ore which is too impure for bing, is further beaten down with a broad headed hammer called a Bucker, according to its degree of mixture with fossils, &c. which this beating is intended to break off,  
and



and prepare for separation in water. This, with what was necessarily broken to an under-size in making bing, they term Knock-bark, i. e. Bucked Ore; which being put into a wire sieve, and washed in a kieve or vat filled with water, the Ore preponderates in the sieve according to its specifick gravity. Thus the smaller parts of the Ore go through the meshes of the sieve into the vat, the larger parts rest on the bottom of the sieve, and the fossil part forms a stratum above the Ore, which is taken off with a semi-circular flat board or hand shovel called a Limp, and is thrown away; and the Ore remaining in the sieve, thus separated, is called Peasy. Those particles which passed through the meshes of the sieve, in separating the peasy from the fossils, with all such small particles of Ore as have been pulverized in getting or dressing, together with those in the waste hillocks, (halvans and henaways) is again washed over in the sieve and vat, once, twice, or three times, in order to separate and cleanse the Ore, which they call Smitham. In this manner are formed the three assortments of Lead Ore, viz. Bing, Peasy, and Smitham. Now in Cornwall these three sorts are generally mixed together for sale; before which, we call the Bing, Cobbed Ore; and the Peasy and Smitham, Jigged Ore, the Peasy being first Bucked. So much in general do the methods of dressing Copper and Lead Ores agree, that in the foregoing account they differ in nothing but terms of art.

There is another method of dressing very tender Copper and Lead Ores, speedier than bucking, viz. in dry stamps, where the Ore has no water to carry it through a grate, but it is stamped dry or a little moistened. In dry stamping, it falls out of the mill, partly in gross lumps; and one attends who with a shovel throws it on a proper sized hurdle, through which the smaller pieces fall; and the larger that run down to the foot of the hurdle, being pounded small enough to pass through the hurdle likewise, the whole is dressed and cleansed by jigging as before.

When the Ores of Copper or Lead are dressed and made saleable in Cornwall (for Lead Ore is disposed of in a different manner in Derbyshire, and the northern counties) the piles or heaps are either kept separate for a market, if the quantities are large; or else the different sorts are well mixed together in one pile, very rarely exceeding one hundred and eighty or two hundred tons in one parcel, and from thence, down to one hundred, eighty, sixty, fifty, forty, twenty, ten, five, or even one



one ton, if the feller pleases, which is seldom the case, and never for his advantage. If a Mine has four hundred tons of Copper Ore dressed ready for sampling, the managers may divide one half of the quantity, for instance, in two parcels of one hundred tons each, and the other two hundred tons thus; one parcel of eighty, another of fifty, another of forty-two, another of twenty-one, and the last may be a small parcel of poor stamped Ore computed seven tons, in all, four hundred. But the reader is not to understand, that these different parcels were ever mixed with each other: they may belong to separate takers upon tribute each parcel, they may lie at several distances from each other, and be of very unequal value; for the first hundred tons may sell for four pounds  $\text{p}$  ton, the next for five pounds ten shillings, the eighty for fifteen pounds  $\text{p}$  ton, the fifty for eight pounds five shillings, and so on of all the rest. It is very common, however, for tributors to mix their Ores with the owners, or with each other of their fellow tributors, so that the Ores of four or five different sets of people may be all mixed together to make one sample for conveniency of sale, pursuant to the directions of the managers or captains of the Mine, previous to which, their separate parcels must be nicely weighed and private samples taken: but I have illustrated this matter in book iii. chap. iv.

A dressed parcel of Ore, before the day of sampling, is very well mixed by several men, who turn it over again and again, a person standing on the top of the pile or parcel, who spreads every shovelful circularly, and as equally as he possibly can, so that in fact, it is mixed with great exactness. This parcel, if less than ten tons, is divided into three Doles or piles; if above ten, into four Doles; and if ever so many more than nineteen tons, it is divided into six Doles; and then it is ultimately ready to be sampled.

Now when the samplers meet upon the spot according to appointment, either of them, indifferently, fixes upon the one-sixth, one-fourth, or one-third Dole of a parcel according as it is great or small, to take their samples from. The Miners then cut or part that Dole athwart and across down to the ground, so that is divided nearly into quarters, by these transverse channels which are cut through it. Then a sampler with a shovel pares down a little of the Ore from all parts of the channels, to take as equal and regular a sample throughout the whole, as he can, to the amount of two or three hundred



weight, which is carried to a clean floor or laid on boards, and there well and regularly mixed in a small heap by itself. Next, a sampler cuts this also into quarters, ordering any two of the opposite or adverse quarters, to be returned to the great Dole from whence they were brought. The remaining half he still mixes and quarters, until it is brought to a small compass or quantity, when it is sifted through a small coarse wire sieve; and the larger stones which cannot pass through the sieve are broken with a sledge or flat polled hammer till all will pass through the meshes. After this, he mixes it very curiously three or four times over; and so quarters and remixes it as before, until it is reduced to a small quantity. Lastly, he puts about a pound or two of it in a small bag, which is a sample of the whole parcel. Each of his brother samplers fills his bag likewise, in order to assay or prove its value by fire, as shall be hereafter shewn.

## C H A P. III.

## A Summary of the Dressing of Gold, Silver, Quicksilver, and Semi-Metals.

**T**H E inhabitants of Africa, and of Brazil, dress their Gold-dust in small bowls, after the manner that Goldsmiths wash their sweeps; and I suspect, that the Spaniards in Mexico, and on the continent, dress their Ore in the same way: but the inhabitants of Brazil will sometimes find a kind of Gold-dust, so very weak and minute, that they cannot save it well in bowls. This has obliged them to have recourse to another method of making the most of this very small Gold-dust, by laying an ox-hide on the ground, with the grain of the hair against the water, which passes gently over it. On this they stir and mix the sand and Gold-dust; by which means, the small particles sink, and are intercepted in the hair of the hide; while the sand washes off. This method seems very rational and well contrived; and Sir John Pettus, in his *Fleta Minor*, says, “The Gold-washers use strong black and russet woollen cloth for the same purpose, in like manner.”

From the several methods prescribed for cleansing Ores by water, it is easy for one who has a tolerable notion of dressing  
Tin



Tin and Copper Ore, thence to conceive, what may be the best way of dressing Gold, or Silver Ore, conformable to the waste or mixture which abounds in either. Yet there can be no certain rules prescribed without seeing the matter to be dressed, because its plenty or scarcity of Metal, the different sizes, the various quantities of its brood or waste, may probably cause great variety in the methods of dressing it; but as rich Ores, on account of their great ponderosity, are easier cleansed than any others; so also, in respect to their intrinsic value, they require a more curious and artificial management and operation. I have seen some sorts of pure Silver Ore, which contained near one half pure silver, the waste being a light Quartz, somewhat transparent: now to dress a quantity of this, I should advise its being bucked small, and then I should prefer jigging before any other way of washing it. I should chuse this method of dressing a quantity of Gold and Silver Ores, provided they were rich in quality, or contained much Gold and Silver in proportion to the waste in them; but if there were little Metal in the Ore, so that it would not well answer the charge of jigging, in that case I should rather wash it in a strêke, on which I would try an experiment of fixing an ox-hide as above, or rather of covering the strêke with a flannel cloth, or the like, to intercept and retain the fine particles of Metal: but this is not to be understood of such Gold or Silver as is intermixed with base Metals or Minerals; for then the methods of cleansing Tin, Lead, and Copper Ore must be pursued, and afterwards the Gold or Silver may be extracted by fire, S. A.

As for the Ore of Quicksilver, it is generally ponderous, and therefore may be dressed like other Ores. Iron Ore, I doubt, will scarce defray the charge of cleansing, and perhaps it needs washing but seldom, because it often rises rich with very little mixture.

Thus, according to one or other of the foregoing methods for dressing of Ores, may the Semi-metals of Bismuth, Cobalt, and Antimony, be cleansed by water, and by comminuting them more or less in proportion to their richness and ponderosity. As for those Minerals which are soluble in water, as Alum, Copperas, and all Mineral Salts, they must be extracted from their impure mixtures by means of water only, in which they must be further purified.



## B O O K V.

### C H A P. I.

On the Art of Assaying Ores and Minerals ; describing the Utenfils and Fluxes for Assaying.

**I**T is not here proposed, to teach the art of assaying Ores, so as to determine the quantities of Metal they contain with such accuracy, as is necessary for those who buy Copper or Tin Ores, that being a peculiar trade : nothing but instruction by a good assayer, and much practice in the business, can make a man a perfect adept in the art. What is intended here, is, only to give the principles of assaying, with such an idea of the practice as may help a person to attain that degree of proficiency which will enable him to form a pretty good judgment of Mineral subjects in regard to their contents. And if a man hath a genius for such sort of enquiries, with that degree of diligence and attention which usually accompanies it, it is possible that what is here said, may open the way for a more scientifick and extensive knowledge and practice of assaying, than is at present known or used in the county of Cornwall ; for whose use this little essay is chiefly calculated and recommended.

To the forming a comprehensive idea of Ores, &c. a man ought to know the natural history of those things which enter into their composition, which are the Metals, as Gold, Silver, &c. and the Semi-metals, Bismuth, Cobalt, Antimony, &c. Brimstone is also a very common and almost a constant concomitant of the Metals and Semi-metals in Ores, as well as stones or earths, which in Cornwall are almost always of the vitrifiable kind, that is, such as run into glass with fluxing materials ; as the fixed salt of vegetables, pearl ashes, and salt of tartar ; nitre, divested of its acid by means of any inflammable matter ; borax, and the calxes of Lead ; fluors, or the fusile spars ; clays, and stones, of the vitrifiable or flinty kind. By reference to book i. chap. iii. of this work, the reader will there find the natural history of



of Ores and Minerals, with that of the fluxes necessary for their fusion and the separation of the Metals and Semi-metals they contain. I shall only beg leave, in this place, to add a method of making the white flux for refining of impure Metals; and another method for making the Fluxus Niger, or black reducing flux.

**Black Flux or Reducing Flux.** Take ten ounces of white tartar, three ounces and six drams of nitre, and three ounces and one dram of borax. Powder and sift them through a hair sieve. When equally mixed, put this powder into a wide mouthed bottle, well corked for use. Though the colour of this is not black, yet it is a most excellent reducing flux.

**The White or Refining Flux.** Take two parts of nitre, white tartar one part. Powder them, and throw them by a large spoonful at a time into a red hot crucible. As soon as a portion of the mixture is thrown in, there will be a violent deflagration: when that is over throw in another quantity, and so proceed till the whole is deflagrated. The operator must be careful to prevent fire or sparks falling among the powder, as it will take fire. The matter must be taken out of the crucible, powdered, and put up as the former. It ought to be well corked, as it is apt to run soon from the moisture of the air. There is yet an easier way of doing this, which is, to put the whole quantity of the powder into an iron mortar; then to set fire to it with a red hot poker, continually stirring it till the deflagration is over. When cold, powder and sift it, &c.

The common wind furnace used in Cornwall, is a very good one in general for the purpose of assaying Metals; and it might be made convenient for cuppelling, if it was contrived so as to have a small reverberatory built on one side, to take the flame just as it arises from the furnace. I have given a section of the furnace for melting, and the reverberatory for cuppelling, in plate VI, fig. 1, viz. A, the melting furnace for trying Copper and Tin Ores; B, the reverberatory; C, a hole in its side for introducing the cuppels. The place or opening at C, must have a door of brick clay exactly to fit it, with a small hole in the middle to inspect the state of the assay, which hole must be stopped with a bit of clay. D, the chimney into which the flame passes from A over the cuppel in the reverberatory B. E, iron bars or grate of the furnace. F, the ashes pit, the whole length of the building from G to H. A furnace thus

S f f

constructed,



constructed, is, I think, sufficient for most if not all assays in Metal.

I shall speak of fuel, and the conduct of the fire, when I come to the processes; and shall likewise treat of the vessels used in assaying, and the materials of which they are made: mean while I shall first give the artist a process for discovering the contents of a Mineral in the liquid way, or by a menstruum.

Process I. Calcine the powdered Mineral, or keep it red hot till it ceases to yield any sulphureous flame; and if the white arsenical fumes are discharged, it may be the better. The Ore must be stirred during the calcination, to prevent its running into clots, in which case, it must be powdered anew. Put this calcined Ore into a phial, and pour on it pure double aqua fortis, or spirit of nitre, sufficient just to cover it. Let the phial stand on warm sand, or in hot water, for two hours: if there should be a violent ebullition, and plenty of red fumes, remove and put the phial into cold water, in which it must stand till cold. Drop some of this spirit of nitre into water, and if it lets fall a very white settlement, the Mineral contains Bismuth. Pour about as much water into the phial, as shall be equal to the quantity of aqua fortis or spirit of nitre that was used. Set it on the hot sand or water for an hour; let the phial stand till the solution is quite clear; then pour it off from the Ore, and drop a small quantity of strong brine into it; if a white matter precipitates, the Ore contains Silver, or Lead, or both: continue to add brine till no more precipitates. Pour the liquor from this precipitate, and wash it with clean water, letting the water settle clear before it is decanted off; add fresh water, and repeat the washings till it is sweet. Melt the precipitate with treble its weight of black flux; and, if there is Lead in it, evaporate the Lead in a cuppel, when the Silver, if any, will be left behind. The Bismuth that falls, will be carried off with the Lead; but in order to free the solution as much as possible from Bismuth, it may be proper to dilute it with more water before the brine is added; and if there is any precipitate, to separate it. Try the solution for Copper, by dropping a little of it on a bright piece of Iron; if it leaves a strong full stain of Copper, this Metal may be separated from it by powdered chalk; for by gradually adding the powder, in some time, on the ceasing of the violence of effervescence, the Copper will precipitate in a green powder, called Verditer. Continue to add the powdered chalk, till no more precipitate falls;



falls; wash this as the former precipitate, melt it with black flux, and it will be revived into Copper. The solution should be kept in hot sand, or water, during the whole time of the precipitation.

In the above process, the spirit of nitre being the proper solvent of Silver, Copper, Lead, and Bismuth, if any of these matters are in the Ore they are dissolved; that is, after the sulphur is burnt off, which would otherwise guard them from being attacked by the spirit. It is expedient, that there should be a larger quantity of spirit than is just necessary to dissolve the Metals, otherwise they might precipitate one another; it is therefore right, to taste the solution; and if it tastes very sharp and acrid, the quantity of spirit hath been sufficient. To make this experiment as accurate as possible, in regard to quantity, the calx ought to be finely levigated in a glass mortar; and the affusion of spirit of nitre, and the digestion, &c. continued as often, and as long, as any thing metallick can be gotten from the calx.

Process II. To assay Pyrites, Marcasites, or Mundicks, for Gold or Silver.

Light a fire in the wind furnace, with common coal; and when it is got up to a good white heat, place a crucible in it, which should be first dipped in water to prevent its cracking; surround it with coal almost to the brim, and as soon as it is of a good strong heat inclining to whiteness, put into it the Mundick designed to be assayed, which ought to be previously weighed. Shut the opening of the furnace with the bricks used for that purpose. Let it remain till it is perfectly fused; then pour it into a cone, greased, or rather smoked by the flame of a candle; when it is cold, knock it out of the cone, and separate the reguline or metallick part from the scoria, if any on the surface of it. A cone is a hollow vessel made of cast Iron. See fig. 2, plate VI.

Process III. The method of scorifying this Mundick, or converting all the parts which compose it (except the noble Metals) into Glafs.

Place a crucible of the largest size, on a piece of brick suitable to it, in the middle of the wind furnace. Make a fire round it with charcoal till it is red hot, when common pit-coal  
may



may be used. Then put in the Regulus of the Pyrites or Mundick, with one half its weight of Lead revived from litharge, and as much Glas of any kind, with as much litharge as Glas, previously mixed together. Raise the fire till all is melted, and the sulphur and arsenick appear to rise through the Glas a-top, and fly off in a flame. Continue the fire for some hours, till this appearance ceases, and the Glas melts smooth like oil, when it may be supposed the sulphur and arsenick are consumed and the scorification pretty far advanced. In this part of the operation, it will be necessary, from time to time, to make fresh additions of litharge to thin the Glas, which is apt to grow thick and tenacious by the Iron (which is continually scorifying) mixing with it. When the litharge is thrown in, it ought to be mixed up with the Glas a-top, by means of an Iron rod. The Glas ought to be very thin before the whole is poured out; when this is the case, pour it out into the greased or smoked cone; and when cool, knock it out, and separate the scoria from the Lead at bottom. If the Lead is quite soft and malleable, and the scoria very thin, so that if a wire was dipped in them, they would have dropped off it like oil, leaving only a varnished like appearance on the wire; the operation is well done: but if the Metal is brittle and hard, the operation must be continued till it is rendered quite soft and malleable. Sometimes it is necessary to make an addition of fresh Glas, in order to a complete vitrification of the Iron, but then litharge must be added at the same time.

When the Lead is reduced to perfect softness, it is fit for cupellation. To carry this process to perfection, it is necessary to bring the scoria to a complete vitrification, when they will be very thin and shining. They are then to be powdered, and mixed with their weight of black flux, a little powdered charcoal, and one quarter their weight of sea salt decriptated: the whole is to be perfectly fused, till it flows like oil, when it is to be poured into the cone; and, when cold, the Lead in the bottom, which is like to be in considerable quantity, must be also cupellated, but separately from the other, in order to determine if the first assay was perfect or not.

The intention of the above process, is to separate the sulphur and the arsenick from the Mundick; and to convert the Iron, which makes up a great part of this compound, into scoria; and finally to vitrify it so, that the Gold and Silver it may contain shall be absorbed by and left in the Lead; which I think is perfectly



perfectly well done by this process. The sulphur and arsenick, are continually flying off through the Glass, which is likely to detain any of the nobler Metals, which the arsenick might otherwise volatilize; at the same time, the Iron which was mineralized by them, burns to scoria, and rising a-top of the metallick part mixes with the Glass, and is vitrified with it; the Mundick at bottom grows more and more metallick, and, as I apprehend, the Lead, if not entirely, is at least greatly mineralized by the sulphur and arsenick. The Iron and Lead, in this Mineral state, are mixed; but the Iron parting from these matters easier, as well as attracting them stronger, than the Lead, discharges them up through the Glass, and is gradually turned into scoria, till the whole of it is separated from the Lead, leaving with it the nobler Metals it contained.

The only hazard of missing in this process, is from the vessels being corroded by the Glass of Lead, which is very penetrating, when brought to that thinness by the litharge which is necessary; but this may be effectually prevented by the use of a porcelain or china-ware crucible, which as it is a new invention, and may be of great use to the curious in Metallurgy, without remarking on what others have done, I shall here give it to the publick in few words.

Process IV. Whoever hath been conversant in Mineral chymistry, must know, that vessels which will hold Glass of Lead, prove a great desideratum. Now the micose clay, which is one part of china ware, is known to be absolutely unvitriable; for though mixed with an equal part of vitriable stone, it stands the greatest heat that art knows, without being vitrified.\* I believe all the grouan clays would answer to make the vessels in question; and, I know that the porcelain clay at St. Stephen's will. The composition I would recommend, is two parts of the washed clay, and one part of the gravel it contains, ground to a very fine powder, mixed and made into a paste. Let a potter form them into the shape of coffee dishes of a moderate thickness, and of different sizes, according to the purposes they are designed for. They must be burned in a crucible, or with crucibles, or porcelain, if you are in the neighbourhood of a factory of either kind. The fire must be full as strong as is necessary to burn china ware or crucibles; but if one hath not the advantage of a neighbouring pottery, the highest heat that

\* See book i. chap. iii. upon Steatitæ, or Soap-rock.



can be given in a smart wind furnace, is sufficient. When burned, they are a true unglazed porcelain as it is possible; the St. Stephen's clay without mixture, may make the strongest vessels; it might be tried: but I know common porcelains answer extremely well.

As these vessels will by no means bear an open fire, they must be guarded: the best way of doing which, is to place them in crucibles made round, and about two-thirds of an inch, or an inch wider. Lay in the bottom of the large crucible the thickness of half an inch of flint sand; if this cannot be had, Quartz, or (as it is improperly called in Cornwall) Spar, may be powdered and sifted through a hair sieve: fill up the vacancy between the two crucibles with the sand or powder, and let the outside crucible have a cover made to it exactly like that of a teapot, and the apparatus is finished. See plate VI, fig. 3. This apparatus must be fixed on a conical base made of two parts pipe clay, and one part sand; the shape of it is to be seen plate VI, fig. 4, a little excavated at top, to let in the crucible that it may stand steady.

I have thought proper to give this process on Pyrites, as there has been much contention about the matter; people will now have it in their power to know whether or not they are of any value.

Any Ore that is supposed to contain Silver, or Gold, mixed with a proper quantity of litharge, with revived Lead at bottom, and a mixture of Glass, if the Ore has no vitrifiable stone in it, may be tried the same way. The want of vitrifiable stone or earth, may be known by the scoria, which will be tough and metallick, not glassy.

Litharge is easily revived, by mixing it with a proper quantity of black flux, and a little charcoal dust, and melting the whole in a strong fire, till the surface melts smooth and equal, without bubbling.

Process V. Cupellation; and the separation of Silver and Gold by Aqua Fortis.

The vessels used in this process, are called Cuppels, and are formed ordinarily of bones burned white and powdered, or of the ashes of vegetables from which the salts have been thoroughly separated



separated by water. But for the formation of cuppels, I refer to Cramer's Art of Assaying, or Maquer's Chymistry, where the manner of doing it is very rightly directed. Some of these cuppels are made in moulds, and others in Iron rings. The former are inverted frustums of a cone, much about the size of fig. 5, plate VI, which is a section of a cuppel. The others are formed in Iron rings, larger or less at pleasure. The method of forming them, is to fill the ring with the bone or other ashes, or a mixture of both. The ashes are brought much to the same temper of moisture with water, as sand is for casting Metals: the sand is then beat down as close as possible, and a hollow place is formed in the cuppel, for holding the Metal. These cuppels are made either round or oblong. The kind of fig. 6, plate VI, may be used, four or five inches wide; which will work off four or five pounds of lead.

As the cuppelling furnace will hold several tests, when one wants to cuppel, it is right to put three or four dry cuppels into the reverberatory with their bottoms upward. Light a fire in the wind furnace, and raise it gradually till the cuppels are red hot; then set one or more of them with their hollows upward, and with a small Iron ladle put the Lead to be tried into one of the cuppels: the Lead is usually beat flat, and cut into pieces, which will melt immediately and contract a scum, and if the fire is sufficiently strong, in some little time the scum will separate, and discover the melted surface of the Metal, as bright as Quicksilver. If the process goes on well and right, there will be little particles or drops resembling oil, continually rising on the surface of the Metal, which will be thrown off to the sides, and absorbed by the cuppel. The fire is to be constantly and uniformly kept up, so as to keep the assay in this way of working, till the Lead is all converted into litharge, and the Silver or Gold sets on the cuppel. Expertness in this process is only attained by practice. Cramer's description of it, is very exact; but as the furnace here directed, is different from his, it is necessary to observe, that if the fire wants to be suddenly quickened, fresh lumps of coal, or small pieces of dry wood, are to be thrown into the wind furnace, by just opening one of the bricks that cover it. When the assay is too hot, a covering brick or two may be taken off, or even the stopper in the reverberatory left open, till the heat is sunk to a proper temper. The marks of too great or too small a degree of heat, are accurately described by Cramer.

Weigh



Weigh the grain left on the cuppel, and see what proportion it bears to the Mundick assayed; from whence it is easy to calculate the quantity of noble Metals, in any given quantity of the Mundick. Lead reduced from litharge is used in this operation, as it contains no Silver, at least so inconsiderable a quantity, as is not worth attending to.

Process VI. To discover, whether the product of the assay contains Gold, and the quantity it contains.

Pour on the grain, four or five times its weight of proof aqua fortis; place the phial on warm sand, and if the Silver entirely dissolves without any black sediment, it contains no Gold; but if there is any black sediment, this is Gold. Pour the solution of Silver from it, and pour water on it, shaking the whole; let this water settle, and then decant it off into the solution of Silver; repeat this till the water has no bitter taste. Wash out the black powder into a small tea dish; and when it is settled, pour off the water from it, and dry this powder of Gold by placing the dish on hot sand. Weigh the powder, and make the calculation. If the Gold is in so small a quantity, that you have no scales or weights nice enough to weigh it, the Lead must be enriched by the operation of scorification, being repeated with the same Lead, on three or four more parcels of fresh Mundick.

If the grain or bead of Metal contains much Gold, say as much, or more, or even one-third of Gold, the aqua fortis will not dissolve it; in which case, three or four times its weight of Silver (which contains no Gold) may be melted with it, or so much as will render it dissolvable in the aqua fortis. The Silver may be precipitated from the solution, by evaporating the water from it in a suitable china-ware vessel set in hot sand, till the quantity is properly reduced; that is, till the water used in washing the Gold is mostly evaporated from it; when by putting clean bits of Copper into it, the attraction between the aqua fortis and the Copper, being stronger than with the Silver, this latter will be precipitated in the form of a white shining powder, to be separated from the bits of Copper. If clean bright pieces of Iron are put into the solution, the Copper will be precipitated; and alkali salt will precipitate the Iron. Wash this precipitate till the water is no longer saline; evaporate the whole, and what is left will be a true good nitre, formed by the



the spirit of nitre, and the pot-ash ; the vegetable alkali being the basis of nitre.

Process VII. Proof Aqua Fortis.

Take any quantity of good aqua fortis, which will dissolve Silver ; drop into it a few drops of a saturated solution of Silver : if there appears to be any precipitate or cloud of a white colour, as there will if the aqua fortis has spirit of salt in it, which I believe is always the case ; if this precipitate falls soon to the bottom, it is proof the aqua fortis contains much spirit of salt, and one may be bolder in dropping in the solution of Silver ; but if it is thin and light, it is necessary to proceed with more caution. Let this milkiness settle ; and to a small quantity of the aqua fortis in a phial, add a drop of the solution of Silver ; and if there still appears a milkiness, more of the solution may be dropped in, always aiming to add no more of the Silver solution, than is necessary to separate the whole of the spirit of salt from the aqua fortis, which may be known by adding a drop of the solution to a little of the aqua fortis in a phial ; for if the aqua fortis is proof, it will continue quite clear without the least milkiness.

There is an easier way of preparing proof aqua fortis, which is by putting a bit of Silver into it, and shaking it several times in a few hours ; and if, the next morning, it is settled quite clear, and any of the Silver is left, it is proof. The only question is, whether it doth not contain Silver ; to determine this, drop a few drops of it into filtered brine, and if there arises no cloudiness in the mixture, the aqua fortis contains no Silver.

Spirit of salt will not dissolve Silver ; but being dissolved in aqua fortis, there is a stronger attraction between the spirit of salt and the dissolved Silver, than between it and the aqua fortis, as it dislodges the spiritus nitri, and unites with the Silver into a salt that is not dissolvable in water, and so sinks to the bottom in a white curd called Luna Cornea, which may be reduced into Silver with pot-ash, by being melted with it ; and if the pot-ash is not in too great a quantity, it will be converted into a sea salt, with a vegetable alkali basis ; by which it appears, that the sea salt was decomposed, or separated from its mineral alkaline basis, in the operation of precipitating the Silver. What is called the Mineral Alkali, or Basis of Sea Salt, is of the



same nature with the Barilla or Soda, used in the preparation of French and Spanish soaps.

I have been thus particular in describing the process of preparing proof aqua fortis, as it is a very necessary menstruum in metallurgical experiments.

As it is possible the Mundick tried, may contain Copper in so large a quantity as not to be entirely scorified by the above operation, but may possibly remain on the cuppel in a considerable quantity; in this case, the bead must be dissolved in proof aqua fortis containing no Silver, or that yields no cloud dropt into clean brine. If this bead contains Gold, it will remain undissolved in a black powder as is said above; wash it, and add the water to the solution, into which, drop brine as long as any white precipitates: this is the Silver in the shape of the Luna Cornea, and when washed and dried may be weighed. I think four parts of it contain three of Silver, or thereabout.

#### Process VIII. To assay Tin for Gold.

To eight ounces of melted Antimony, put two ounces of the Tin to be tried; keep them together in a moderate fire, till they melt together and flow like oil, without the least bubbling or effervescence, which operation may take an hour. If the mixture grows thick, fresh Antimony is to be added, till it melts perfectly thin or fluid; then pour it out into the Iron cone, and when cold separate the bright antimonial regulus at bottom, from the scoria at top: set by these scoria. Heat a cuppel made of crucible clay, or the bottom of a crucible, reduced to the shape of a cuppel (these vessels are called Tests) in the reverberatory, till it is of a strong red heat inclining to white; place the regulus of Antimony in it, which will instantly melt. Direct the nose of a kitchen bellows on this test, and keep up a continual blast on the regulus (which will evaporate in thick white fumes) till it is reduced to one quarter or less of its original weight. Take out the test and let it cool; separate the remaining regulus from it, and melt it in a crucible. Throw on it twice its quantity of nitre; and when the deflagration and fumentation are over, pour it out into the cone. If there is any Gold left, and this Gold is fine, the operation is complete; but if there is nothing left at the bottom of the yellow glassy scoria, the Tin contains no Gold. If there is a small button of brittle Metal, or Metal not sufficiently malleable,  
add



add equal parts of nitre and borax, and repeat the operation, till the Gold is quite fine; when it is to be weighed, and the proportion it bears to the Tin assayed, determined.

In this operation, the sulphur which mineralizes the Antimony, having a greater attraction with the Tin, than with the regulus of Antimony, deserts the regulus, and lays hold of, and mineralizes the Tin, with which it ascends among the melted Antimony; whilst the regulus separated from the Antimony, descends, and mixes with the Tin at bottom. This process goes on till the whole of the Tin is mineralized by the sulphur, and somewhat a greater quantity of the regulus separated and precipitated; if the Tin contains any Gold, it will be mixt with this regulus, as sulphur cannot mineralize it. If there is any Silver, this will be mineralized, and raised among the scoria, which consist of the Antimony in its Mineral state, and the Tin reduced to this state; the regulus containing the Gold, being volatile, is evaporated in white fumes, by the second operation, whilst the Gold is left: but as it is difficult to bring it to perfect fineness this way, nitre is used in the finishing operation, which immediately calcines the regulus. In this operation, the spirit of nitre evaporates along with the phlogiston of the regulus, and the alkaline part of this, together with the reguline calx, melts into glassy scoria of an amber colour, leaving the Gold untouched by the nitre, which cannot dissolve it.

Process IX. To try the first scoria for Silver.

Melt the first scoria, consisting of the mineralized Tin and Antimony, in a crucible; throw powder of nitre on them, and there will then be a considerable deflagration; continue to throw in more nitre till the deflagration ceases, and when the matter in the crucible melts like oil, pour it into the cone, knocking it gently that it may settle. When it is cold and struck out of the cone, carefully examine the apex of the melted scoria, where the Silver will be found if the Tin contained any.

In this process, the phlogiston of the sulphur is carried off by the spirit of nitre; and the other part of it, viz. the vitriolick acid, is attracted by, and united with, the alkaline basis of the nitre, forming with it a true sal polycreston, that swims at the top of the melted scoria, which by this process, are converted  
into



into a compound *crocus metallorum*, consisting of the calcined Antimony and Tin. The Silver not being calcinable, when the sulphur which mineralized it is separated by the nitre, it regains its metallick form, and falls to the bottom of the cone.

The compound *crocus metallorum*, and the amber scoria, may be reduced into a metallick form, by being mixed with a proper quantity of black flux, and melted in a crucible; but not without great loss of the regule. This process for the separating Gold from Tin by Antimony, may be applied to Copper, or any other Metal.

Process X. To assay Copper Ore.

Powder the Ore and sift it through a hair sieve; shake and mix it together, that every part of the powder may be alike, in regard to its metallick contents: form this powder on a piece of paper into a bed of half an inch thick; then weigh off a troy ounce, or ounce and quarter of it, from different parts of the bed or heap: and in order to assay it, the Ore is first to be calcined, in the following manner:

The wind furnace having been before well heated, is to be filled with sea coal, reduced to the state of charcoal, or as it is usually called, coakt or charkt. A crucible of the largest size for assaying, is then placed in the furnace, so that the top of it shall be a little beneath the top of the furnace. It is very proper to place one layer, or a few pieces of raw coal, round the top of the crucible, to keep down the flame and heat, which would otherwise incommode the operator in the calcination. The Ore may now be put into the crucible, and some of the covering bricks put on the mouth of the furnace to raise the fire; but this must be done gently. As soon as the Ore is observed to be of a dusky red, it is time to begin to stir it, to prevent its melting and running into lumps, which must by all means be prevented, both by stirring, and a proper regulation of the fire. The Iron rod used in stirring, should be about two feet and a half long, and as thick as the end of the little finger, the one extremity of it flattened and formed like the toes of a pair of tongs, so as to suit the bottom of the crucible. With this rod the Ore is to be stirred briskly from time to time, so as to prevent its melting, or running into lumps; and if it should appear disposed to do this, it must be stirred very briskly, till the appearance ceases, and the Ore is again reduced into a powdery form.



form. It will not be necessary to stir the Ore continually ; but when you cease to stir, the rod must not be taken out of the crucible but left in it, the upper end resting on the bricks of the chimney.

In the beginning of the calcination, a large quantity of sulphureous and arsenical fumes will be discharged from the Ore ; and most Ores, at this time, emit also more or less of a sulphureous flame. As the Ore parts with these volatile matters, it grows less fusible, so that the fire may be suffered to encrease a little, in proportion as the Ore is less liable to melt. The operation must be thus continued, till the Ore emits no longer any visible fumes. When the crucible is taken out of the fire and smelt at, if it yields no smell of sulphur, even when it hath been exposed to a strong red heat, a little inclining to white, then it is sufficiently calcined. This process generally takes three quarters of an hour, and the fire must be often renewed by adding fresh charks, and raw coal.

In this process, the Ore is freed from the sulphur and arsenick which mineralized it, and is now reduced to the Metals and stony substances ; but as the Metals cannot be collected by fusion into a body, as the stony parts are infusible, this makes it necessary to use such things as will turn these stony matters into Glass, by the following process of Scorification.

Process XI. Supposing the quantity of Copper Ore made use of, to be one ounce, mix with it one ounce and a quarter, good weight, of black flux, and half a thimble full of powdered culm ; put these into the crucible the Ore was calcined in, and cover them with nearly half an ounce of sea salt. Fill the furnace with charks, and place the crucible in the furnace, surrounding it with charks to the brim. After you have covered it with a cover, made of the same composition with the crucible, put on the covering bricks on the mouth of the furnace, when the fire will rise, and the matters in the crucible will be heard to melt and boil. When these appearances have ceased for some time, remove the bricks, and inspect the matters in the crucible ; if the surface is agitated, and the boiling and fermentation continue, the scorification is not complete. If the fire wants mending, mend it ; place the crucible securely, close the furnace, and continue the fire, till the contents of the crucible flow like oil. Take it out of the furnace, and suffer it to cool ; when cold, break the crucible, and separate the Metal at bottom,

X x x

from



from the scoria. If these appear to be quite glassy, lucid, and black, and if they contain no grains of Copper, the scorification is well done.

In the above process, the nitre and tartar are converted into an alkaline salt, which being rendered still more vitrescent by the borax, convert the stony matters contained in the calcined Ore, together with a part of the Iron in it, into a true glass, to which the blackness is given by the Iron. As this glass is very fusible and fluid, the grains of Copper now reduced to Metal, easily find their way through it, and unite at the bottom into one piece of Metal. The salt is added as it contributes to vitrification, and prevents the matter from rising in the pot, and leaving grains of Metal on its sides, which would falsify the assay. The powder of culm is put in, to supply phlogiston, after what the tartar contained is burned off; and if the operation is continued after this, there is danger of the Coppers being burned, and deprived of its phlogiston; in which case, the assay will be covered with a red shining heavy friable substance, which is the calcined Copper melted: to guard against this, the powdered culm is added.

The quantity of flux may be varied, according to the richness of the Ore. Very rich ones will require much less than what is ordered; nothing, however, but practice and experience, can enable a person to fix the quantity of flux requisite. The furnace for scorification ought to have a smart draught; for if the operation takes up much time, the assay is apt to burn; about fifteen or twenty minutes is sufficient for the most part, if the furnace is a good one.

The lump of Metal from the first melting is scarcely ever fine, being mixed with Iron, Lead, Tin, or possibly with all these Metals; therefore to separate them, it must be refined, for which the following is the process:

#### Process XII. Refining the impure Copper.

Fill the furnace with charks, and place a crucible of the second size in it. Let the fire rise till the bottom of the crucible is white hot, when the button of Copper is to be put into it, by means of a small pair of forceps or tongs purposely contrived for it. As soon as the Copper is seen to melt, throw on it, by means of a small Copper scoop, about as much white flux as will



will lie on a half crown; there then will be a great boiling and fermentation in the crucible: when this ceases, pour it into the ingot first smoked or greased; and when the whole is set, plunge it in water to cool it; separate the scoria, and set them by in a ladle. If the button of Copper is not fine, this operation must be repeated until it is, which is known by the brightness of the colour, its malleability, and breaking with a fine grain. This operation is generally repeated three or four times, or more, before the Copper is quite fine.

As the white flux contains a large quantity of nitre, and the aqua fortis in it corrodes Iron and Tin more readily than it does Copper, those Metals are turned into calx by it, and separate in the form of scoria along with the flux: some of the Copper, however, is always corroded, and turned into scoria; therefore, to render the assay perfect, this must be recovered and brought to Copper. In order to this, the next operation or process is necessary, which is

**Process XIII.** The reduction of the scoria; and also the refining the prill.

Dry all the scoria of the former process which were set by in the ladle; beat them to a powder in the small Iron mortar, and mix with them about their own weight of tartar powdered, and a little powdered culm: cover them with a layer of salt, and melt them as in the process of scorification. When the whole is melted perfectly, and flows like oil, pour it into the smoked ingot. The reduced Copper, or as it is more usually called by the Cornish assayers, the Prill, will be found beneath the flagg. This, too, is always impure Metal, some part of the other Metals being reduced along with the Copper; the prill must therefore be carefully refined as above, with the white flux, adding some salt immediately after the flux is thrown in. The refined prill is then to be added to the button of Copper, and both weighed, to determine the quantity of fine Copper, which the Ore contained; from whence a calculation may be made, of the contents and value of a ton of Copper Ore.

The refining the prill is a very nice operation, which the Cornish assayers perform with singular expertness. They judge the effect of their fluxes very nicely, and help them by keeping the assay in the fire for some time before they pour it; for fire has the same effects with nitre in reducing the imperfect Metals

to



to a calx, only it does it flower: the Iron, Tin, and Lead, calcining quicker than Copper, the effect of fire in refining is very evident. Nevertheless, the successful management of it, can only be attained by attention and experience.

In Copper assays, the cone is not used, but an ingot of a peculiar kind. Hollows of a spheroidal form, are made in a piece of Iron or Steel about an inch thick. These excavations are polished very smooth, and the utensil hath a handle formed out of it, see fig. 7, plate VI. The hollows contain about half an ounce of water, and are nearly an inch and quarter diameter. Some smoke these hollows with the flame of a candle, and others rub them with grease, or a rag inclosing some tallow, rosin, or wax.

Process XIV. To assay Copper Ore the regule way.

Pulverize, sift, and mix the Copper Ore, as in the tenth process; then take the the same quantity of Ore, with an equal part of common powdered black glass, about a fourth or a fifth part of nitre, and half as much borax: mix and put them all together in the crucible, covered with one quarter of an inch thick of common salt. Melt these in the strongest fire you can raise in the wind furnace till they flow freely, which will take some time longer than a sample of calcined Ore. When cool, break the crucible, separate the regulus from the scoria, pulverize it, and then proceed exactly in the same manner as with a calcinable Ore, ut supra.

Now, in order to calculate the value of a ton of Copper Ore by the produce of an assayed troy ounce, you are to remember, that if one ounce of Ore makes one pennyweight of fine Copper, it will be one part in twenty, five pennyweights will be five parts in twenty, and so on: therefore, a person who is familiar in the business, may know the value of a ton of Copper Ore off hand, by only asking, how many parts in twenty such a sample has produced. But this valuation of an assay depends entirely upon a given standard price for the ton of fine Copper, be it either ninety, ninety-six, one hundred, or one hundred and five pounds sterling. Of course, every pound or twenty shillings that the standard rises or falls, will make a difference in the assay of one shilling or a twentieth in every pennyweight, and a halfpenny in every grain: as for instance, one pennyweight, one grain, at ninety-five the standard, will make the produce  
equal



equal to four pounds fifteen shillings the pennyweight, and three shillings and eleven pence halfpenny the grain; but if the standard is ninety-six, the produce must be valued at four pounds sixteen shillings the pennyweight, and four shillings the grain. Three pennyweights and three grains at ninety-five the standard, will amount to sixteen pounds sixteen shillings and tenpence halfpenny, and at ninety-six will rise to seventeen pounds.

This mode of calculation being apprehended by the reader, I will proceed to a few examples by the rule of practice, which will set the matter in so clear and easy a light, that any person may calculate an assay of Copper Ore without the least difficulty.

Suppose one troy ounce of Copper Ore produces an assay of fine Copper that weighs — Dwts. Gr.  
 at ninety pounds the standard value of one ton of fine Copper, I first multiply the three pennyweights by four pounds ten shillings the standard; for ten times three shillings are thirty shillings, and four times three pounds are twelve pounds, and with the twenty shillings from the place of shillings make one pound more, equal to thirteen pounds ten shillings: so that three pennyweights of fine Copper at ninety, is worth thirteen pounds ten shillings the ton: but here are nineteen grains unaccounted for in that price; therefore, I say, twelve grains are one half of a pennyweight, equal to two pounds five shillings; six grains, the half of that, are equal to one pound two shillings and sixpence: and the one grain remaining, is equal to ninety halfpennies; for, as I have said before, one grain is valued at so many halfpennies, as the standard is pounds; therefore one grain is equal to three shillings and ninepence. By adding the whole together; I find the assay of three pennyweights nineteen grains, at ninety, is worth seventeen pounds one shilling and threepence  $\text{per}$  ton of Copper Ore. These are the gross proceeds; but as there is an expence upon the bringing this ton of Ore into fine Copper, such as carriage of the Ore to the coal by land or sea, or both, furnaces, labour, coal to smelt it, &c. it must be deducted before we can fix the nett value thereof. These returning charges are commonly rated at three pounds  $\text{per}$  ton one with another; so that, of consequence,

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one hundred tons of Copper Ore will require three hundred pounds expence to bring them into fine Copper ; and the above seventeen pounds one shilling and threepence will be reduced to a nett value of fourteen pounds one shilling and fixpence ; it being customary to reckon no pence below fix.

Nevertheless, in some Ores, these returning charges at three pounds are over much ; for if it requires but that money to smelt Ore of fifty shillings nett value  $\text{£}$  ton, it certainly cannot take the same to smelt Ore of thirty or forty pounds ; as many of our rich gray Ores (which are naturally regulized) and native Copper demand but two or three flowings to be thoroughly refined. All these things are properly judged and considered by the purchasers, who may add or diminish their estimates of returning charges as they chuse, the seller being generally as ignorant of the whole as any person unconcerned in the affair. I shall subjoin two or three assays at different standards, which may be calculated by the foregoing rule ; premising, that if the reader would know the quantity of Copper Metal in one ton, or any given number of tons of Copper Ore, he must divide four hundred and eighty by the produce of the assay, and the remainder by twenty, and that will shew what quantity of Ore will make a ton of fine Copper.

|                                | Dwt.      | Gr. |                       |
|--------------------------------|-----------|-----|-----------------------|
| An assay of fine Copper weighs | 1         | 19  | at 95 the standard.   |
|                                | <u>£4</u> | 15  |                       |
|                                | 2         | 7   | 6                     |
|                                | 1         | 3   | 9                     |
|                                |           | 3   | 11½                   |
|                                | <u>£8</u> | 10  | 2½                    |
| Deduct for returning charges   | £3        |     | such as smelting, &c. |
| Nett value                     | <u>£5</u> | 10  | 6 $\text{£}$ ton.     |

An



|                                | Dwts. | Gr. |                     |
|--------------------------------|-------|-----|---------------------|
| An assay of fine Copper weighs | 4     | 13  | at 96 the standard. |
|                                | £4    | 16  |                     |
|                                | £16   |     |                     |
|                                | 2     |     |                     |
|                                | 1     | 4   |                     |
|                                | 2     | 8   |                     |
|                                |       | 4   |                     |
|                                | £21   | 16  |                     |
| Deduct for returning charges   | £3    |     |                     |
| Nett value                     | £18   | 16  | ⌘ ton.              |

|                                | Dwts. | Gr. |                      |
|--------------------------------|-------|-----|----------------------|
| An assay of fine Copper weighs | 2     | 7   | at 100 the standard. |
|                                | £5    |     |                      |
|                                | £10   |     |                      |
|                                | 1     | 5   |                      |
|                                |       | 4   | 2                    |
|                                | £11   | 9   | 2                    |
| Deduct                         | 3     |     |                      |
| Nett value                     | £8    | 9   | 6 ⌘ ton.             |

## Process XV. To assay Lead.

If this Ore is pure, that is, free from Mundick or the like, the process is very easy. With an ounce of the powdered Ore mix about eight or nine pennyweights of fresh Iron filings. Melt the whole together in a pretty strong fire till it flows perfectly thin; then pour it into a greased cone or ingot; and, when cold, separate it from the scoria at top. If the separation should be difficult, put the whole into an Iron ladle, and when the ladle is red hot, the Lead will melt, and run from the scoria, and will pour out perfectly fine Metal.

As through the violence of the heat in the first melting, the Lead will take into it some of the Iron used in fluxing it; it is therefore



therefore necessary to remelt it in an Iron ladle, when the Iron will immediately rise at top, in form of scoria, when the Lead may be easily poured off, and the scoria will be left in the ladle. A little tallow may be added before the Lead is poured off, which will reduce some of the Lead that was burned, and increase the produce.

In this operation, the Iron having a stronger attraction to sulphur than Lead, frees the Lead from it, which by this means is reduced to its metallick form.— The Iron is also mineralized by the Lead, which is evident, by its melting the Mundick shine, which those scoria exhibit when broke; but especially by falling abroad when exposed to the air, and being convertible into copperas, just in the same manner as the sulphureous Marcasites are.

If Lead Ores have arsenical pyrites mixed with them, the assay is more difficult; for in this case, they must be calcined like Copper Ores, and all the arsenick must be evaporated. By adding powdered charcoal in proportion to one quarter the weight of the Ore, it will expedite the calcination, and prevent it from running into lumps, which it is very apt to do.

When it is calcined, it must be mixed with its own weight, or more, of black flux, and about a quarter or fifth part of Iron filings; put on them a layer of salt, and melt down, till it flows thin; then pour it out, and treat the Lead as was done in the former process, to free it from the Iron.

The use of the calcination in this last process, is to discharge the arsenick, which renders the Iron easily fusible; and if the Ore was not calcined, would fall down, in a reguline form, together with the Lead, and render it impure. Besides, it would cause an imperfect separation of the scoria, and keep up a great deal of the Lead amongst them; for, as this arsenical regulus would incorporate with the Lead, the mixture would be much lighter than Lead. The Iron filings are added, to absorb the vitriolick acid that may be left in the Ore after calcination.

Lead is assayed for Silver or Gold on the cuppel, as directed before; and all the Silver it contains above twelve troy ounces in the ton, is profit.

Process



Process XVI. To assay Tin Ore, called Black-Tin.

The method of assaying Tin Ore is very easy; for in its form and size of Black-Tin (which is the Ore dressed by stamping, several washings, and calcination, if mineralized with vitriolick, arsenical, or sulphureous pyrites) great part of the work is done to the assayer's hand; so that little more remains, than to proceed to immediate fusion, which is presently accomplished by a red heat, in the following process.

Take four or five ounces of Black-Tin as emptied from the sacks; mix it well with about one-fifth part of its weight of powdered culm; put the mixture in a Black-Lead crucible on the wind furnace, and in twenty minutes (more or less, according to the strength of the fire, and the greater or less fusibility of the Ore) you will find the Metal precipitated as far as may be to the bottom of the crucible, the culm and scoria floating on the Tin, not in a vitrified, but loose unconnected state. You will generally see globules of Tin lying on the surface of this matter; you should therefore with an Iron rod stir the mixture, by which means most of those globules will fall through it into the Tin at the bottom. Close the furnace, and let the whole remain in fusion from three to five minutes. Keep by you an Iron or Brass mortar, and an ingot mould of about six inches in length, fig. R, plate VI. Pour the Tin into the ingot, and empty the culm and scoria into the mortar, scraping off what remains in and about the crucible (which should always be of the Black-Lead kind) with a sharp iron. As soon as cold, put them into another mortar and pulverize them, first in a small degree, so as to separate the scoria from the largest of the globules of Tin, some of which will always remain therein after pouring out the ingot as before directed. Select the larger globules, and pulverize the remainder a second time; then put this stuff so twice powdered on a shovel, and passing it often through water, in the same manner as the lighter parts are washed from Ore in vanning, you will have the smaller globules remaining on the shovel; and these with the larger (both together generally called Pillion-Tin) being added to, and weighed with the ingot, shew the produce in Metal of the four or five ounces assayed.

Process XVII. To assay Cobalt.

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Take



Take a bit of the Mineral supposed to be Cobalt, with its weight of borax ; put both into a broken china cup, and blow on them with a blow-pipe till they are perfectly melted and vitrified. If the china-ware is tinged blue in the spot where the Ore was placed, it contains Cobalt. But as some Ores contain Cobalt and Mundick together, in which case the Iron would render the Glass black, the best way is regularly to assay the Ore which is supposed to contain Cobalt, as follows:

Calcine an ounce of the Ore in the same manner as Copper Ore is directed to be calcined, only the calcination need not be carried so far ; for as soon as the sulphureous flame evidently disappears, it is sufficiently calcined. Melt the calx with black flux, as directed in the scorification of Copper Ore. Pour it out in the ingot, and melt a little of the regule with five or six times its weight of flint glass, and a little borax, for half an hour in a small crucible. If the glass is of a fine blue colour, the regulus is pure ; but if the glass is black, it contains Iron, and must be refined with the white flux, in the same way as is directed in refining the Copper assay. As long as the scoria are black or brown, the regule contains Iron ; but as soon as the scoria, and sides of the crucible, are tinged blue, it is fine : and if this does not happen, when the whole of the regule is consumed, the Mineral contained no Cobalt. The goodness and value of the Mineral is estimated by the quantity of pure regulus it contained. If there is any Silver or Bismuth mixed with the Cobalt, they will neither of them mix with the cobaltine regulus ; but, on breaking the pot, will be found quite distinct from it : and it is the same if the matter is poured into an ingot.

This regulus is not to be made malleable, but from this process is evidently that which strikes the colour : for a further proof, take two ounces of smalt or powder blue, mix it with its weight of argol or tartar, and it will deposit in fusion the regulus that gave the colour. May it not be fairly concluded from hence, that all the Semi-metals which strike any colour, will deposit a regulus which is the efficient cause of it ? But the knowledge of this valuable branch of Mineralogy is yet in its infancy with us.

#### Process XVIII. To assay Bismuth.

Bismuth



Bismuth is easily separable from its Ore, and may be procured pure by melting the Ore in a crucible in a moderate fire, without any flux; but if it is very impure, an addition of the black flux will soon fuse it: however, the fire must not be too fierce, for if it be, the Bismuth will be lost.

To discover Silver in Gossans or very poor Ores.

Any Gossans or very poor Ores which are supposed to contain Silver, being calcined and mixed with three times their weight of litharge, may be assayed as directed in the process for assaying Mundick; only there will be no need of Glass, as the Ores are supposed to be stony. Care must be taken, that the scoria are thin at the last, either by the continuance of the fire (by which litharge will be formed from the Lead at bottom) or by the addition of litharge, as directed in the aforesaid process. The china-ware crucible is also best here.

#### C H A P. II.

Of Smelting of Copper Ores in the great Furnaces called Copper Works.

**T**O form a just and general idea of the construction of furnaces, and of the disposition of the several apertures in them, with a view to increase or diminish the activity of the fire, it will be proper to lay down, as our ground-work, certain principles of natural philosophy founded on experience.

First, Every one knows that combustible matters will not burn or consume unless they have a free communication with the air, insomuch that if they be deprived thereof, even when burning most rapidly, they will be extinguished at once; that, consequently, combustion is greatly promoted by the frequent accession of fresh air; and that a stream of air, directed so as to pass with impetuosity through burning fuel, excites the fire to the greatest possible activity.

Secondly, It is certain that the air which touches or comes near ignited bodies, is heated, rarefied, and rendered lighter than



than the air about it, that is further distant from the center of the heat, and consequently that this air so heated and become lighter, is necessarily determined thereby to ascend in order to make room for that which is less heated and not so light, which by its weight and elasticity tends to occupy the place quitted by the other : another consequence hereof is, that if fire be kindled in a place enclosed every where but above and below, a current of air will be formed in that place, running in a direction from the bottom to the top ; so that if any light bodies be applied to the opening below, they will be carried up towards the fire ; but, on the contrary, if they be held at the opening above, they will be impelled by a force which will drive them up, and carry them away from the fire.

Lastly, It is a demonstrated truth in hydraulicks, that the velocity of a given quantity of any fluid determined to flow in any direction whatever, is so much the greater the narrower the channel is to which that fluid is confined, and consequently that the velocity of a fluid will be increased by making it run from a wider through a narrower passage. These principles being established, it is easy to apply them to the construction of furnaces.

The materials fittest for building furnaces are, bricks joined together with potter's clay mixed with sand, and moistened with water ; potter's clay mixed with potsherds, moistened with water, and baked in a violent fire : also Stourbridge clay, and many of our talcy clays to be had in great plenty in the Cornish soft grouan strata, mixed and baked in the same manner.

The only kind of furnace for smelting Ores where bellows are not employed, is what is called a Reverberatory Furnace. The Germans call it a Wind Furnace. It is also distinguished by the name of English Furnace, because the invention of it is attributed to an English physician. The Copper furnaces bear four names, viz. the Calciner, which is the largest ; the Operation, Roaster, and Refiner, which are all of one gauge or nearly so both in shape and size.

The hearth or bed of the calciner should be eighteen feet long and thirteen feet wide within, by two feet ten inches at a medium from its concave back to the bottom, which must be flat. The fire place three feet four inches long, by two feet wide and two feet deep, so as to have two feet of flame to pass over



over the Ore in calcination. The length and breadth of the masonry of this furnace should be in proportion from out to out as they express it, viz. twenty-four feet long, by eighteen wide.

Fig. 14, plate VI, represents a longitudinal section of a reverberatory furnace used in the smelting of Copper Ores: 1. the masonry; 2. the ash-hole; 3. a channel for the evaporation of the moisture; 4. the grate; 5. the fire place; 6. the inner part of the furnace; 7. a basin formed of sand; 8. the cavity where the melted Metal is; (that is, in the refinery, because the Metal there is not tapped but laded out by an Iron ladle, therefore the bottom is concave, but those of the operation and roaster are flat) 9. a hole through which the scoria are to be raked or removed; 10. the passage for the flame and smoke, or the lower part of the chimney which is to be carried up to a height of about thirty feet; 11. a hole in the roof, arch, or crown of the furnace, where the Ore is put in—This furnace is eighteen feet long, comprehending all the masonry; twelve feet broad, and nine and a half feet high—The hearth or bottom is raised three feet above the level of the foundery: on one side is the fire place, under which is an ash-hole hollowed in the earth; on the other side is a basin made, which is kept covered with fire when there is occasion: on the anterior side of this furnace there is a chimney, which receives the flame after it has passed over the Ore that is laid upon the hearth. This hearth, which is in the interior part of the furnace, is made of a clay capable of sustaining the fire. This furnace has a hole in its front through which the scoria are drawn out; and a basin, as we have said, on one side, made with sand, in which are oblong traces for the reception of the regulus, matt, or black Copper, when the furnace is tapped.

The inside of this furnace is commonly an elliptick curve; because it is demonstrated by mathematicians, that surfaces having that curvature reflect the rays of the sun, or of fire, in such a manner, that, meeting in a point or line, they produce there a violent heat. The most advantageous size of the melting area of this furnace is seven feet ten inches long, four feet eight inches broad, and two feet high at a medium. The fire place two feet eight inches long, by two feet wide, so as to form one foot nine inches fire: the refining furnace has also two side doors, one for raking or skimming, the other for lading.

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Fig. 15, plate VI. represents the upper plan of the furnace of which fig. 14 is a section: 1. the outer wall; 2. the draught-hole communicating with the ash-hole; 3. the door through which fossil coal is thrown into the fire place; 4. the place where an opening is made to let the melted Metal flow out of the furnace; 5. an opening through which the scoria are raked and drawn off; 6. the bason made of sand where the Metal lies; 7. the fire place with an Iron grate; 8. a small partition one brick thick between the fire place and the area of the furnace, over which the flame passes—This is called the Bridge.

Copper is generally mineralized, not only by sulphur and arsenick, but also by Semi-metals and pyritous matters, and is frequently mixed with other Metals. As this Metal has great affinity with sulphur and arsenick, it is almost impossible to disengage it from them entirely by roasting: hence in the smelting in great, nothing is obtained by the first operation but an impure Copper, which contains all the principles of the Ore, excepting the earthy and stony parts, particularly when the Ore is smelted crude and unroasted. However, the Copper Ore when brought to the works in some few places is refined by repeated smeltings and roastings without calcination: but as I propose to describe all the processes for its ultimate refinery, I shall begin with that of calcination, which in most places is nearly thus.

A certain quantity of the Ores, called a charge, from ten, to thirty, or forty hundred weight, is put into the calciner, where it is frequently stirred in such a heat as will not melt it, during a tide or twelve hours, more or less as the nature or mixture of the Ores require: two, three, four, or five hundred weight of this Ore is then put with five, four, three, or two hundred weight of raw Ore into an operation furnace. The fire is made very intense, and the whole becoming fluid and thin at the end of four hours the slag is skimmed or drawn off through the hole of the furnace no. 5, fig. 15, plate VI, by an Iron rake called a Rabble. Another like quantity of Ore is put in, and the same manœuvres being thrice repeated, the greater part of the remainder, being thus skimmed, in a state of fluidity, and under a great heat, is at the end of twelve hours let out by a tap-hole in the side of the furnace no. 4, fig. 15, plate VI, into a bed of sand where it forms itself into pegs or pigs, and is now a regulus. These pegs are taken before they are cold, and on Iron wheel barrows are conveyed and plunged into a trough or cistern



cistern of cold water. From thence the regulus is carried to a horse mill, and there reduced almost to a powder. In some places this is done by women, girls, and boys, for the sake of employing them, which they term bucking the regulus, and is performed the same as bucking described in our chapter upon dressing Copper Ores. In this condition it is carried to a furnace, called a Metal Calciner, where a quantity from fifteen to forty hundred weight (according to the capacity of the furnace) is spread over the bottom, and, by such a fire as will not just melt it, again calcined for about two tides or twenty-four hours. From thence it is drawn out, cooled by water, and carried to the Metal furnace, where it is fused, skimmed, and tapped out at the end of twelve hours in pegs, much in the manner of the operation furnace before described. The roasting furnace next takes this Metal (as the workmen call it, though it is very far from being in a state of malleability) whole in the pegs, where they are roasted sixteen or eighteen hours, and when the fire is risen, they are melted, skimmed, and tapped as before. This operation of roasting and flowing, &c. is repeated three or four times; some Copper Metal evidently appearing in it, it is carried to the coarse refining furnace, from whence when melted, skimmed, and ready for its exit, it is not tapped, but taken out in Iron ladles and thrown into oblong Iron pots or moulds by a ladle full at a time, each mould containing about one hundred and a half. A quantity of this fine Copper from sixteen to twenty-five hundred weight according to the capacity of the furnace and usage of the works, is put into the refiner, or refining furnace, where being again melted by an intense heat, skimmed, and otherwise rendered proper for the purpose, it is again laded out in such shapes and quantities, as the master or director of the works requires, and may best suit the rolling mill, the battery mill, or the other demands of the manufacturers.

I shall make no mention of extracting the small quantities of Copper and heterogeneous Metals which remain in the slags or scoria skimmed off in the several operations, which after extraction is often mixed with some others to make those inferior Metals called Pot-metal, Manillions, &c. nor of the several kinds of fluxes which are few and differently used by different operators, neither can it be of service to any but an adept in the business. My intention is only to give a general idea of the processes in smelting as far as they have fallen under my observation, and not meddle with the private manufactory or economical



mical applications of those objects of trade and commerce. The reader may observe how much more tedious, difficult, and expensive the refinery of Copper is, compared to that of Tin, and therefore may be less surpris'd at the difference which sometimes happens to be between the buying price of Ores, and the selling price of Copper. That we may illustrate the labour, expence, and complicated calcinations, roastings, smeltings, and meltings, for the refinery of Copper, which do not amount to less than twelve or fourteen operations, we subjoin an estimate of the consumption of coal in working one hundred tons of Copper Ore.

|                                                                                                                                                                                                                                                                                             | Weys     | Ch.     | Bush.    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---------|----------|
| To calcining fifty tons of Ore, one chaldron of coal to four tons — — — —                                                                                                                                                                                                                   | 6        | 0       | 18       |
| To reduce ditto with fifty tons of raw Ore to a regulus, each two tons of Ore requiring one chaldron of coal — — — —                                                                                                                                                                        | 25       | 0       | 0        |
| To calcining forty-two tons of ditto, each ton holding thirty parts of Copper in one hundred of regulus, one chaldron of coal to two tons of Ore — — — —                                                                                                                                    | 10       | 1       | 0        |
| To melting thirty-eight tons of ditto, the other four being evaporated in the calcination — — — —                                                                                                                                                                                           | 9        | 1       | 0        |
| To bring forward in the roasters fifteen tons, thirteen hundred of Metal from the regule, holding eighty parts of fine Copper in one hundred, divided into ten loads, each requiring three roastings to bring it to coarse Copper, each roasting consuming eighteen bushels of coal — — — — | 7        | 1       | 0        |
| To refining the same, being twice laded —                                                                                                                                                                                                                                                   | 6        | 1       | 0        |
| To reduce the slags of the whole supposing them thirty tons — — — —                                                                                                                                                                                                                         | 7        | 1       | 0        |
|                                                                                                                                                                                                                                                                                             | <hr/> 72 | <hr/> 1 | <hr/> 18 |

Thus



Thus we see that the Copper of pyritous Ores cannot be obtained without several operations, which vary according to the nature of the Ores. These operations are chiefly by roastings and fusions; and by the interference of calcinations in some portion of the same Ores likewise. By the first fusion a matt or regulus is produced, which is afterwards to be roasted; and thus the fusions and roastings are to be alternately applied, till by the last fusion Copper is obtained.

These methods of treating pyritous Ores depend on the two following facts: 1. Sulphur is more disposed to unite with Iron than with Copper. 2. The Iron of these Ores is destructible by the burning sulphur during the roasting or fusion of the Ores, while the Copper is not injured. This fact appears from the daily practice of smelting cupreous Ores highly impregnated with Mundick that is either sulphureous or arsenical.

From these facts we learn, that sulphur may be employed to separate and destroy Iron mixed with Copper; and that on the other hand, Iron, or Gal, or Gossany Ores, may be used to separate the sulphur from Copper; so that by adjusting the proportion of sulphureous-mundicky, arsenical-mundicky, and Gossany Copper Ores, to each other in the smelting, those substances may be made to destroy each other, and procure a separation of the Copper, in which the greatest art and mystery of the smelting business consists. (Scheffer, Schlutter, Margraaf, Macquer.)

The first Cornish Copper Ores (in order I suppose to avoid having the process of smelting divulged) were carried to Bristol. A palpable mistake was committed in this case, as it was necessary to sustain a double expence of carriage. This was, however, soon rectified; and most of the different companies erected their Copper works in some spot of Wales, convenient for the carriage of the coals from a neighbouring colliery; and likewise with the advantages of a little harbour. It is a circumstance of some importance, while we consider this affair, to observe, that, as the numerous fire engines employ a large fleet of colliers to supply their demands, so the back carriage of the Ore is by no means so considerable as it would otherwise be. But let us turn our eyes to the flourishing state of Swansea, Neath, and those other parts of Wales, which have been so very fortunate as to become the factories of the different Copper companies; and let us consider those populous towns as owing  
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their existence and wealth to our indolence and inattention. The evil hitherto has seemed irremediable to the spiritless inhabitants of our county, from the vast opulence of the different companies, whose interest it must be to support the present system, the channel of their wealth. They know, that it would require a greater purse than any one or two private gentlemen are able to furnish. It was however attempted, about seventy years since, by Mr. Scobell, at Polruddan in St. Austle, with whom Sir Talbot Clark and Mr. Vincent joined, where the first piece of Copper ever made so in this county, was smelted, refined, and brought to perfection. After this John Pollard, Esq; of Redruth, and Mr. Thomas Worth, of St. Ives, made a second trial; but both these attempts failed of success, more through ill management, roguery of the workmen, and the improper situation of their works, than any extraordinary charge of the fuel. After these, one Gideon Cofier, of Piran Zabuloe, erected an house for the like purpose at Pen-pol in the parish of Phillack, but being soon taken off by a Fever, when he had made a fair progress in it, the same was carried on by Sir William Pendarves and Robert Corker, Esq; who have both assured the writer (Thomas Tonkin, Esq;) that they could smelt their Ore as cheap (all hazards considered) as the companies could pretend to do at their works in Wales. They did so accordingly for some years; but being since dead, and their affairs falling into such hands as had other interests to mind, this project too sunk with them. A small beginning was also made to the same purpose at Lenobrey in St. Agnes, where they smelted some Copper with good success; but were obliged to give it over for want of a sufficient stock to go on with it.

From all these infant essays and some observations made and gathered from workmen abroad, but chiefly from the late Mr. Cofier, largely concerned in the White Rock Works at Swansey, who owned to Mr. T. that most of our Ores might be smelted nearly as cheap here as abroad; I am convinced (if we allow for the great salaries the said companies are obliged to give to their agents here and elsewhere; the hazard of Ore on ship-board in time of war, and double freight to pass and repass our own inhospitable coast, with the risk of being cast on their native shore) nay, I believe it would amount to a demonstration, that it might be done much cheaper and more advantageously in some convenient places in this county than in Wales. Notwithstanding this, it has been the refinement of Cornish policy to suffer

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the exportation of their raw staple, in order to give other countries the benefit of its manufacture !

To remedy this intolerable grievance, a proposal was made to some of the principal gentlemen of the county, to join in a petition to her Majesty Queen ANNE (and had not her sudden death prevented it, it might have been effected) that her Majesty would be pleased to lay it before her parliament, to have our Copper Mines subject to the stannary laws in all things (except being under bounds) and have the Copper coined at the neighbouring coinage towns, as the Tin is, under a duty of one shilling & hundred of fine Copper to be paid to the Duke of Cornwall ; which, as it would be an addition to the ducal revenue, and managed without any surcharge by the same coinage officers, so would it effectually secure the smelting and refining all the Copper Ores within the county, by degrees let us into the true value of our commodity, and the management of it, as easy as that of Tin ; and furthermore confine the labour and profits in the manufactory thereof among ourselves. This small memorial of the above design, Mr. T. says, he has left behind him to be digested in better order by wiser heads, whenever they see convenient season to put it in execution. (Anonym. Address, Tonkins MSS.)

Thus far had been attempted the smelting of Copper Ore in Cornwall, which it must be owned had been frustrated through the confederacy of opposite interested companies, and the want of sufficient insight into the art of fusion more than from the attributed extraordinary expence of fuel ; till about the year 1754, when one Sampson Swaine, in conjunction with some gentlemen of Camborne, erected furnaces at Entral in that parish ; but their situation being too remote from coal, they removed their works to Hayle. The author very well remembers the combinations which were formed to overthrow this laudable effort. The companies left no method unsought to traduce the credit, and stab the vitals of this undertaking. Threats and remonstrances were equally used to oblige or cajole the owners of the Mines to abandon or suppress the new company at Hayle. The opponents of this association using every expedient to mortify the spirit of this arduous undertaking, alternately raised the price of Copper Ores, and lowered the value of fine Copper, to the great loss of the contending parties ; which will ever be the case where monopolies are disturbed, and the almighty power of opulence can prevail. But happening to  
have



have men of fortune and capacity at their head, they were founded in prudence, and withstood the shocks of power and artifice.

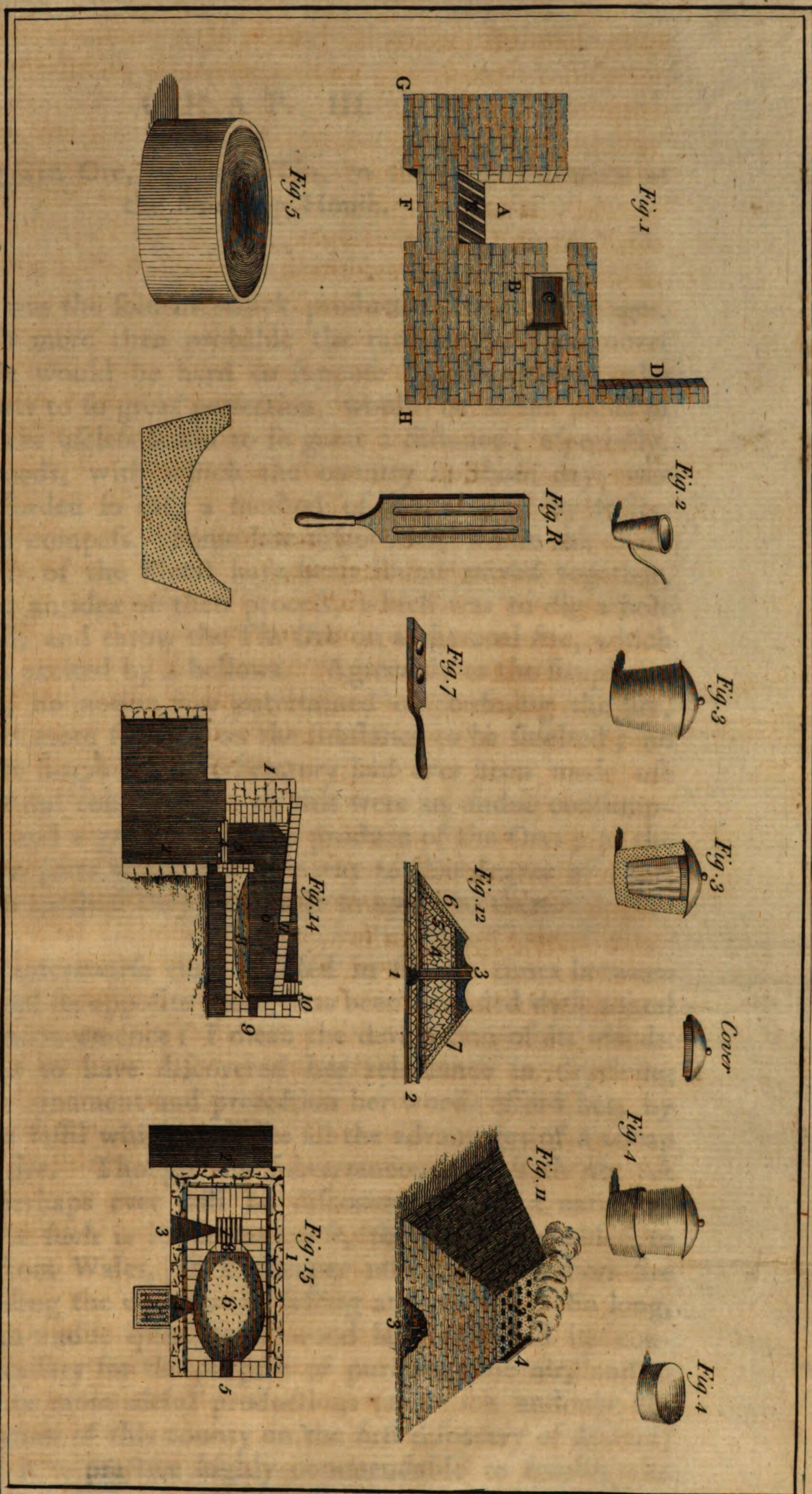
That it will answer to smelt Copper Ores on this side the channel, is undeniably demonstrable by the thriving situation of this Cornish Copper Company, who would not so vastly increase the number of their furnaces without having experienced the benefit of their undertaking.

Similar to that, another company erected works at North-Downs in Redruth a few years back. Perhaps their small beginning did not excite the notice of the other companies: however, their industry and œconomy have been successful; and after having enlarged their works in that unfit place, at a great expence, they have now removed the same to Tregew, on a branch of Falmouth harbour, for the more profitable conducting the concern. I have further to add, from the best authority, that they are thriving under this removal and many other disadvantages. It is much to be wished, that some spirited gentlemen would imitate their example; and as such a step would be of great advantage to themselves and the community, I will suppose they will, e'er long, see with their own eyes and judge for themselves.

In this little history of smelting Copper, no notice hath been taken of those who attempted the practice of boiling and roasting at the same fire. In fact, nothing could prosper in such hands. Neither can we commend the temerity and improvidency of those who built their furnaces like churches, upon the same plan; not well considering, that a heat for the fusion of stubborn Ores, can scarcely be too focal or concentrated.

C H A P.





To Sir Frederick Lemon Rogers, of BLACFORD in Devonshire, Baronet.  
 This Plate engraved at his expense, is most gratefully Inscribed, by  
 W<sup>m</sup> Pryce.







C H A P. III.

Of Smelting Tin Ore, or Black Tin, in the great Furnaces at the Smelting-House.

**A**S Tin was the sole metallick produce of the earlier ages, so it is more than probable the raw Mineral was never exported. It would be hard to suppose the Phenicians, who carried the arts to so great perfection, would be at the pains of transporting the useles scoria to so great a distance; especially, when the woods, with which the country in those days was over-run, afforded so easy a method of reducing it by fusion into a smaller compass. Some late discoveries, where the charcoal and dross of the Metal have been found mixed together, have given us an idea of their process, which was to dig a hole in the ground, and throw the Tin Ore on a charcoal fire, which probably was excited by a bellows. Agreeably to the simplicity of the times, no notion was entertained of confining the fire, to make it act more forcibly on the substance to be smelted; no furnace either simple or reverberatory had ever been made use of. The natural consequences of this were an undue consumption of fuel, and a great loss in the produce of the Ores; as the more stubborn parts would not give way to that degree of heat, which by this method they were able to apply to them.

The little intercourse that subsisted in former times between this county and its opposite shore, has been attended with a fatal and lasting inconvenience: I mean the devastation of its woods. Nature seems to have discovered her reluctance in depriving herself of the ornament and protection her woods afford her, by substituting a fossil which possesses all the advantages of a cheap and durable fire. Though this subterraneous fuel hath not yet been, nor perhaps ever will be discovered to be a native of Cornwall, yet such is its portableness, that we are enabled to procure it from Wales, at a cheaper rate than common fire wood, including the expences of felling and carriage. So long, indeed, as an undue quantity of wood land rendered its consumption necessary for the purpose of purifying the air, and to make room for more useful productions (and such undoubtedly was the situation of this county on the first discovery of Britain) so long was it a practice highly commendable to employ the

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super abundant fuel to so beneficial a purpose. But when we behold a wide and barren waste, extending itself throughout the whole Mining district of this county, without a tree to intercept the fury of the wind, we have no reason to commend the prudence of our ancestors, in thus depriving their demesne of its necessary shelter.

It is still a pleasing reflection to consider, that one of the most essential maxims of state has been constantly adhered to, I mean that of manufacturing their Tin at home. The practice at first was obvious: the wood probably grew on the margin of the shaft from whence the Ore was raised, and it must have been necessary to clear large spots of it, to give the Miner room to place his Tin-stuff and erect his engines. The great demand for this article which no known part of the world at that time produced, occasioned a scarcity of fuel to be very early felt, and the heavy expence of fetching wood from distant parts naturally enhanced the price of Tin. The discovery, or, rather, the introduction of sea coal, made a great alteration in the Mining system: this valuable substitute came into general use, and put a stop to that ravage of coppice which was travelling insensibly to the eastward; and though the observation may be new, yet it appears clearly to me, that we stand indebted to our neighbours the Welch for even the small quantity of wood land that still remains in the eastern part of the country.

Necessity at last suggested the introduction of pit-coal for the smelting of Tin Ore; and among others, to Sir Bevil Granville, of Stow, in this county. Temp. Car. I. who made several experiments, though without success: neither did the effectual smelting of Tin Ore with pit-coal take place, till the second year of queen Anne, when a Mr. Liddell, with whom Mr. Moulton, a noted Chymist, was concerned, obtained her Majesty's patent for smelting Black Tin with fossil-coal in Iron furnaces. The invention of reverberatory furnaces built with brick, stone, sand, lime, and clay, soon followed this discovery; the form of which, being simple, has admitted little improvement to the present time.

The Tin smelting furnace differs little from that made use of for smelting Copper, only it is not quite so deep, as it is tapped at every charge. The charge for one of these furnaces is from five to six hundred weight of Black Tin, well mixed with a tenth or a twelfth its weight of culm. This furnace is charged through  
a hole



a hole in the side (directly opposite to the tap-hole) through which it is thrown into the furnace with a shovel, and levelled over the bottom with an Iron rake or paddle from the mouth. This done the apertures are immediately closed, and the fire raised to a very great strength, in which state it is left between four and five hours, when the door is taken off, and the whole charge is well stirred together. The foreman of the work at this time examines the state of the Metal, &c. and if he thinks it convenient, orders an additional quantity of culm, at his discretion, to be put into the furnace, which is closed again and left in this condition, the fire all the time being kept fully up, till the end of about six hours from its receiving the charge; at which time it is again examined by the foreman, and, if he finds it proper, is then tapped, and the Metal let out into a fixed basin made of clay, and of a capacity to hold something more than the Metal of the charge: as in some sorts of Tin the scoria being vitrified to a considerable degree, part thereof will flow out with the Metal; but this is not commonly the case in any large quantity. The scoria remaining in the bottom of the furnace is raked out at the mouth, and falls into a small pit under it made for the purpose, and has generally adhesion enough to form into a cake. As soon as it is cold, it is carried to the stamping mill in order to separate the globules of melted Tin disseminated through the scoria or slag. The scoria being broke by hammers to the size of goose eggs, are put into the first stamping mill, and passed through small Iron bars, (instead of a holed Iron plate) none passing through those bars above the size of a horse bean. By this means the pillion (for so all Tin recovered out of the slags is called) of the larger size is taken out, and thereby prevented from waste by too much stamping. The refuse of this first stamping is put into other stamping mills of a second, a third, and even some part thereof into those of a fourth size. The pillion in the first and second of the stampings is separated from the scoria in the same manner as Copper Ore from its waste, and that of the slimes of these, together with the third and fourth stamping, in the same method as Tin Ore at the stamping mills. Of the pillion so separated, all the rough or grainy parts are considered as Metal, and refined accordingly by being smelted without any flux, and the produce of this smelting refined with the Tin first tapped. The sandy and slimy parts of the pillion resembling stamped Tin Ores, are treated as such, and are mixed and smelted with them.

I now



I now return to the Tin in the bafon, or float, as it is called ; which, as soon as it is come down to a moderate heat, is laded out into the moulds, in flabs or pigs, of about three quarters of an hundred weight ; not larger, because they would be too unweildy to heave into the furnace for refining, to which I now proceed.

The furnace having, by the fide of the small float juft now described, a larger one capable of holding twenty or more blocks, is for this purpose fuffered to cool to a certain degree, and then charged full with the flobs juft mentioned, the tap-hole being kept open, fo that as the Tin melts in this moderate fire, it makes its exit through it into the float, where while running out it is frequently ftirred and tossed by a ladleful at a time held arm high, letting it fall in a ftream into the mafs of Metal, when the fcum which arifes is taken off. While the Metal already put into the furnace is melting, more is added, fo as to be juft enough to fill the float with good Tin : and this after being tossed and skimmed as before, and fuffered to cool to a proper temper, is carried in Iron ladles to moulds holding generally fomewhat above three hundred weight, (then denominated Block-Tin) where they are marked as the fmelters choofe, with their houfe mark, which may be a pelican, a plume of feathers, a ftag, or a horfe, by laying Brafs or Iron ftamps on the face of the blocks while the Tin is in a fluid ftate, yet cool enough to fustain the ftamping iron. The blocks are then ready to be weighed, numbered, and fent to the neareft coinage town to be coined.

There yet remains in the furnace the drossy part with which the Tin was contaminated, and which, not melting with the flow fire made use of, holds with it a confiderable portion of good Tin. The fire is, therefore, now encreased, fo as to melt the whole ; which is then tapped out altogether into the small float, where the Tin fubfiding, and the dross rifing to the top, the latter, foon cooling, is taken off and fet by, and the Tin laded into small flabs as at firft to be again refined. The furnace is now charged again as before ; and after cleansing again, generally employed to fmelt Tin Ore as ufual. The Tin that remains in and about the fcoria and dross of the laft tappings, &c. is recovered by repeated fmeltings, till at laft being almoft entirely drained of that Metal, they become what the workmen generally call Hard-heads, confifting of fuch heterogeneous Metals



Metals as were included in the first mixture, and esteemed of no further value.

The qualifications of a good Tin smelter are a thorough knowledge of the different kinds of Tin Ore, and of the nature and principles of the different Metals and Minerals mixed therewith; as on this knowledge, not only the making good Metal, but also getting the full produce of the Ore, must entirely depend; and for the want thereof, nothing, not even great care and long experience, can compensate. It is to the want of this insight in the smelting business, or at least to an inattention thereto, that we are to ascribe the great quantity of bad Tin which is passed the coinage every quarter; much to the shame of the Tin smelters, and still more to the reproach of Stannary government, for suffering a place of great trust and profit to become a finecure to some mercenary borough man! Yea, even worse, a cloak for ill proceedings. Were these matters properly attended to, and the duty of the assay-master strictly enforced, it would operate more towards preventing foreign importations of Tin into Europe, and extending the sale of our own, than any, or all other regulations that can be made respecting the Tin trade!

Four supervisors of the Tin in Cornwall and Devon, were first appointed by king Charles the second. Their office is to inspect the blowing and smelting houses, to see that no cheat or fraud be committed in the blowing or smelting of Tin, and for fundry other beneficial purposes relative to the common-weal of the Stannaries. But of all offices belonging to the Tin, this, though instituted on a very good principle, is now the least regarded. If the supervisors, who now receive each of them eighty pounds  $\text{£}$  annum for doing nothing, were obliged to visit these houses twice a week, their trouble would not be great, and their diligence might answer the end, and make their places serviceable to their country. (Anon. Address; Tonkins MSS.)



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TIN IN THE GREAT TUNNAGES.  
Materials were included in the first mixture, and consisted of  
no further value.

C H A P. IV.

Of the Sale of Copper Ores ; and of Black Tin at the Smelting-House, and after it is smelted and coined in Blocks.

**T**HOUGH the richness of our Copper works is not a late discovery ; yet it is not a hundred years that the knowledge of working them to good effect hath been understood. The most obvious reason is, that it was the interest of the first discoverers to keep the natives in profound ignorance. Mr. Carew, in the reign of Elizabeth, hints at the little profits made in Cornwall from Copper : “ It is found,” says he, “ in  
“ fundry places, but to what gain to the searchers I have not  
“ been curious to enquire, nor they haſty to reveal : for of one  
“ Mine, of which I took view, the Ore was ſhipped to be  
“ refined in Wales, either to ſave coſt in the fuel, or to conceal the profit.” Mr. Norden, one hundred and ſeventy years ſince, ſeems to have had full information that the Corniſh Copper Mines were rich, and, therefore, in his letter to king James the firſt (ſee his Surv. of Cornwall) like a faithful ſervant, intimates the expediency of a better inſpection into the ſtate of thoſe Mines, and ſurmizes the arts by which the value of them was concealed : “ So rich are the works,” ſays he, “ eſpecially  
“ ſome lately found, as by the opinion of the ſkilful in the  
“ myſtery, the like have not been elſewhere found, though the  
“ worth hath been formerly extenuated by private pryers into  
“ the ſecret, and covertly followed for their own gain.” Notwithſtanding theſe hints, we do not find any thing material going on here as to the improvement of the Copper Mines, till, about eighty years ſince, ſome gentlemen of Briſtol made it their buſineſs to inſpect our Mines more narrowly, and bought the Copper Ores for two pounds ten ſhillings to four pounds  $\text{per}$  ton. The gains were anſwerable to their ſagacity and diligence, and ſo great, that they could not long be kept ſecret, which encouraged other gentlemen of Briſtol about ſixty years ſince to covenant with ſome of the principal Miners in Cornwall to buy all their Copper Ores for a term of years at a ſtated low price, particularly with Mr. Beauchamp, the grandfather of the preſent John Beauchamp, Eſq; to buy all the Copper Ore which ſhould riſe out of a Mine well ſtocked, for twenty years, at five pounds  $\text{per}$  ton ;



£ ton; and the Ore at Relistian in Gwinear was covenanted for at two pounds ten shillings £ ton.

About fifty years back great quantities of Copper Ore were risen from three principal Mines in this county; viz. Huel-Fortune in Ludgvan, Roskear in Camborne, and Pool-Adit in Illugan; the produce of which Mines were sold to the few buyers at their own price. The four Copper Companies, viz. the Brass-Wire Company, the English Copper Company, Wayn and Company, and Chambers and Company, being then united and confederated, there can be no doubt of their beholding with a single eye their joint interest and pursuit; till they were interrupted by a gentleman from Wales, who visited this county in order to improve his own branch of business in the same way. Let his motives be ever so selfish, the gentlemen Miners at that time, if not their posterity, were manifestly benefited by his visit; for just then, fourteen hundred tons of Copper Ore, which had been lying unfold some years at Roskear and Huel-Kitty, were offered to this gentleman, and for which the confederated buyers would give only four pounds five shillings £ ton. But so contracted were the principles of the Miners in those days of unremediable oppression, that they obliged this friend to their country to deposit a sum of money equivalent to the supposed amount of their Ores before they would consent to weigh them off at the advanced price they had agreed to take for their commodity. These confined notions will ever prevail where the trade of a country is subject to the domination of rapacious and dishonest combinations. However, this gentleman bought the fourteen hundred tons of Ore at the advanced price of six pounds five shillings £ ton, which he paid for with ready money, and gained much above thirty £ cent. as the writer is well informed from the most indubitable authority! What must have been the profits of companies confederated to serve their own interests without limitation or controul? This new comer bought nine hundred tons more at Roskear at seven pounds £ ton; and in less than six months before he left Cornwall he purchased three thousand tons, upon which he deservedly made, very little, if at all, short of forty £ cent. profit.

Soon after this, the buyers and sellers mutually agreed to ticket for all Copper Ores which should be ready for sale at stated times, and the highest bidder or ticket should be the purchaser. On the very onset of this compact, three hundred tons of Ore belonging to the same Mine were to be ticketed for on a day appointed



appointed, in Redruth, when the agent of the Mine having absented himself some time beyond the limited hour of sale, a certain gentleman of great address, power, and fortune, declared himself the purchaser by private contract at eight pounds seventeen shillings & ton, when one of the ticketers present produced his ticket before all the company, whose offer was nine pounds seventeen shillings & ton, to the shame and confusion of all the adventurers.

It is to this nefarious transaction that we owe the present mode of ticketing for Copper Ores. The proprietors and adventurers in Mines of those times, found themselves in a predicament singularly ridiculous and distressing: they possessed a commodity whose value they could not tell how to ascertain; and the buyers, who were acquainted with every requisite for their own advantage, had formed themselves into a confederacy the most pernicious and destructive to the whole Copper Mine interest of this county. It was impossible that such a state of affairs should long continue. The secret at length transpiring, other companies were gradually formed; and from an opposition and rivalry in trade, the adventurer received a better price for his Copper Ore, though far beneath its just value.

In the beginning of my acquaintance with Mining affairs, about twenty-seven years past, there were six companies established for buying of Copper Ores. At present I think there are thirteen companies, which attend by their agents, and throw in their tickets on the day of sale. It will be necessary to premise that a day of sampling is fixed (see book iv. chap. ii. p. 245) with a fortnight's interval between it and the ticketing day for trying the samples of Ore and receiving answers from their principals. On this ticketing day a dinner almost equal to a city feast is provided at the expence of the Mines, in proportion to the quantities of Ores each Mine has to sell; and the adventurers, with the companies agents, assemble together. Soon after the cloth is removed, the tickets containing the different offers of the different companies are produced and registered by the agents of both buyers and sellers, the originals being delivered to the proprietors of the Mines; and the highest bidders are of course the buyers. In order to evidence the concise and easy method of ticketing for Copper Ores, I have subjoined a duplicate of a ticketing paper, by which the reader may apprehend, at one glance, that ten thousand pounds worth of Ores may be sold and appropriated to the respective buyers in half an hour's time.

By



# COPPER ORES Sampled the

|                    |   |      |          |          | B        |          |
|--------------------|---|------|----------|----------|----------|----------|
|                    |   | Tons | Hore     | Bevan    | Phillips | W Papps  |
|                    |   |      | £. s. d. | £. s. d. | £. s. d. | £. s. d. |
| Roskear            | — | 86   | 5 2 6    | 6 1 0    | 6 0 0    | 6 0 0    |
|                    |   | *68  | 12 4 0   | 10 15 0  | 11 4 0   | 12 19 6  |
|                    |   | 54   | 9 17 6   | 8 14 0   | 9 0 0    | 9 3 6    |
|                    |   | 50   | 11 1 0   | 10 2 6   | 11 2 6   | 11 0 0   |
|                    |   | 42   | 7 3 0    | 7 4 0    | 6 16 6   | 7 15 0   |
|                    |   | 19   | 14 2 0   | 13 13 0  | 14 1 6   | 14 18 6  |
| Huel-Gherry        | — | 44   | 7 14 6   | 7 3 6    | 7 9 0    | 6 17 0   |
|                    |   | 32   | 3 2 6    | 4 1 0    | 3 10 0   | 3 15 0   |
|                    |   | 26   | 4 6 0    | 3 19 6   | 3 18 0   | 3 14 0   |
|                    |   | 9    | 2 2 0    | 1 18 0   | 1 15 0   | 1 17 0   |
| Huel-Chance        | — | 90   | 8 9 0    | 7 19 0   | 8 10 0   | 8 0 0    |
|                    |   | 84   | 6 4 0    | 5 18 0   | 6 6 0    | 6 1 6    |
|                    |   | 56   | 4 2 6    | 6 0 0    | 4 19 6   | 4 12 6   |
|                    |   | 44   | 18 1 0   | 17 2 6   | 17 17 0  | 18 14 0  |
|                    |   | 20   | 3 2 6    | 3 5 0    | 2 19 0   | 2 0 0    |
| Ditto Halvan's Ore |   | 20   | 1 19 6   | 2 2 0    | 2 1 0    | 1 19 0   |
| Stamp Ore          |   | —    | 15       | 1 10 0   | 1 14 0   | 1 15 0   |
| Vivian's Burnt Ore |   |      | 5        | 1 2 6    | 1 3 0    | 0 0 0    |
| In all             |   | 764  | 80       | 130      | 90       |          |

\* This parcel to be equal







By this method, which has subsisted since its first establishment to this time, sixteen thousand pounds worth of Ore are monthly disposed of in entire dependence upon the honour of the purchaser, and which I believe is not to be paralleled in any part of Great-Britain. Sed humanitas et gratior et tutior. Permit me, for argument's sake, to suppose these gentlemen acting on the most honourable principle; yet still there is an unavoidable inconvenience, which may be of the most destructive consequence to the seller. What I mean is this: whenever a purchaser does not want a particular parcel of Ores, or perhaps does not mean to purchase at all, it is usual for the agent of that company to affix a price to his ticket much below his computed value of those Ores. On the supposition of non-communication between the buyers (which is the only foot on which the favourers of the present system rest their cause) it must frequently happen, that all companies must be in the same predicament with respect to some parcels of Ores; the consequence is, those Ores go off at a low value, and become the property of persons who did not mean to buy them. This is putting the case in the fairest light; and, to conceive the mischief which follows, we are to observe, that those parcels amount to very capital sums of money, and that the loss sustained by the proprietors is proportionably large.

I have mentioned, above, the emulation natural to rival companies; but it is to be feared that principle has long ceased to operate: and as there is Copper Ore raised in the county sufficient for them all, they do not wish to push one another. On the contrary, the utmost harmony seems to subsist between them; and the talk of establishing a new company is sure to be followed by an association of the old ones, in order to defeat it.

I know it has been urged, that large quantities of Copper Ores lie at the several furnaces unsmelted, that much Copper remains unfold, and these to the amount of a considerable sum. Admitting this argument, let us for a moment consider the benefit of these pretensions to the purchaser. He thereby pretends, that he is buying Copper which must remain on his hands; and by way of allowing himself interest for his money thus lying dead, he has the modesty to sink the raw commodity from twelve per cent. which is a very handsome profit upon a merchandize unperishable, to thirty, and more frequently to forty, per cent. It is a great pity that the amazing monthly

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expence



expence of deep Mines, joined to the narrow circumstances of many of those concerned in them, should make it necessary for those Mines to sell their Ores immediately for the price they can get; as the withholding those Ores, at a profit of twenty, or even supposing ten,  $\frac{1}{2}$  cent. would make a great difference in their favour on the balance of their accompts. But I forbear to dwell longer on this disagreeable subject, as I am convinced that most of the people concerned in Mining have long beheld with indignation the treatment they meet with, and only want a leader to stand forth in their cause. (Anonym. Address.)

I proceed to observe, in justice to the buyers of Copper Ore, that no payment for any commodity can be more punctual than that which is made by them. I cannot recollect one instance of tardiness in all their transactions respecting their payments; for at the month's end, after the Ores are weighed off, cash or bills of exchange, almost equal in credit to bank notes, are ready for the seller's use. This custom makes Copper Ore a ready money article, which is of the greatest consequence to the necessities of the Miners, and in truth cannot be dispensed with, unless the system of Mining be quite changed. However, it must be confessed that the purchaser receives some gratification to counterbalance his politeness: for every ton of Ore (presuming on a supposition of waste) must weigh twenty-one hundred weight to the ton; moreover, Ore that is wet by rain is allowed for by a further over-weight according to reason and conscience. At Pol-dyfe Mine the managers will not allow more than four pounds upon every three hundred weight be it wet or dry. The samplers demur to this regulation, and contend for four pounds upon dry Ore, and as much more as they can have, for wet. Whoever approves this rapacity must be an enemy to the county of Cornwall; for these allowances of one hundred weight upon twenty, and four pounds upon every three hundred weight, which is one quarter upon the ton (all together equal to six per cent. on the foregoing profits) are more than ten times equivalent for all the wet and waste they can seriously pretend to suffer. Such is the present oppressed state of the Copper trade in Cornwall; upon which representation I shall rest at this time, but with an intention on a future day to lay open the several artifices used in that branch of business in a small pamphlet, for the mature consideration of the proprietors of Copper Mines in this county.

Preparatory



Preparatory to the final disposal of Tin, it must pass an exchange of Black Tin or Ore for White Tin in blocks, by the way of barter between the Tinner and the Smelter, because the latter is not paid in money for smelting the Tin, but by deduction of a certain share in twenty to himself out of the quantity brought to be exchanged. Herein consists a necessary skill in the smelter: for the Metal of the assay of different kinds of Tin Ore being extremely variable, and not properly refinable in such small quantities, and the manner of agreeing for or buying the Tin Ore of all sorts being to give Tin bills or promissory notes to the owners thereof, engaging to deliver them at the next coinage so many hundreds of refined Tin for every twenty hundred weight of the Ore or Black Tin; if the manager in this matter is not a judge how much pure Tin his impure assay will produce, it will become a matter of meer chance whether the Tinner has the real value for his Black Tin, or whether he or the buyer suffers most by the exchange. The smelter's judgment must be exercised also on another score besides that of the fineness of his assay, as he must deduct from the quantity of Tin the seller's Ore will produce, as much as he thinks will pay for the smelting and other incidental charges, together with the profit he proposes to allow himself thereupon.

The assay being made, weighed, and calculated, and a judgment formed what proportion thereof is to be allowed the smelter for his charges and profit, the business is reduced to a short treaty: A has brought to B twenty hundred weight of Black Tin (Tin Ore). Suppose the produce of this Tin twelve hundred weight; B offers to deliver A, for this, eleven hundred weight at the next coinage; which if A agrees to take, a promissory note, commonly called a Tin Bill, is given him in the following terms, or nearly so:

N<sup>o</sup> 123. Carvedras, the 8th day of April 1777.

Received of Mr. Anthony Ashley, twenty hundred weight two quarters and fourteen pounds of Black Tin which at eleven for twenty in White Tin is eleven hundred weight one quarter and nine pounds. Which I promise to deliver to him or bearer this Truro coinage.

For H. R. Esq; and Co.  
White Tin 11 1 9

JONAS MILFORD.



This bill being negotiable and payable by an indorsement, the same as a bill of exchange, the owner thereof may sell it to any one, or at the smelting-house, as most frequently is the case, for some certain value per hundred weight; otherwise he may coin the Tin thereof upon his own account. These bills are frequently bought at a nominal value; the buyer and seller covenanting with each other, that if the real value, when fixed, be different from the nominal, whatever it may be above, the former is to pay to the latter, except one shilling per hundred weight, the premium for laying out his money; if under, the seller is to return the difference, and one shilling per hundred weight, for the reason just given. This method of purchasing is called Buying on Discount; and the most usual way of settling the real price for such Tin has been to fix it at that of the first hundred blocks bought or sold by any one person, of the Tin belonging to that coinage (or quarter) in which such bills were bought.

This makes what they call the Tin bill trade so noted in this county; for if the Tinner is not of ability to wait the time of the coinage, and perhaps some time after, till the merchant wants it, upon which also two or three months credit must be added; he sells the bill for ready cash to the monied man, who defrays all future charges upon the Tin. The buyer has a further profit upon this Tin of two pounds over-weight upon every hundred weight of White Tin, which the smelter is obligated to render the bill-holder; so that the buyer of the bill has about two shillings per hundred weight clear profit by this traffick; and if he can return his money quarterly, which was formerly the case, he makes twelve per cent. profit per annum of his cash. The Tin bill trade was anciently in the hands of the mercantile part of the county, but it now principally rests with the smelters of the Tin, who take care to operate on the credulity of the Tinner by insinuating that he has a larger exchange of White Tin for his Black when he parts with the former to the smelter; and that, in complaisance for his obliging disposition towards the proprietor of the house—This may be true; but, *Fallax vulgi judicium*.

There is one consideration that is connected with this subject, that deserves much more attention than it has ever yet met with. These persons who stand between the real and original proprietors of the Tin-stuff and the exporters, though they have usually the greatest share of the White Tin in their possession, are not

to



to be looked on as the real sufferers by the low price it bears, or even by a stagnation of the Tin trade, unless it is unforeseen. These gentlemen take care to make all proper deductions on that account when the Tin is brought to them to be sampled; and the discount on Tin bills, as I have just observed, is an additional douceur. I would not be supposed even to hint at a combination between the smelter of the Tin and the manufacturer or exporter: the credit and fortune of many of the former place them above a bare insinuation of this kind. I only mean to assert, that however they may join the general cry on account of the low price of Tin, no thinking person will ever set them down as sufferers thereby. There is a known fact I shall mention by way of illustration, viz. That the retailer of any exciseable commodity stands in the same predicament, with the merchant who buys to sell again, and has as much reason to be a loser on an additional duty laid on that commodity; whereas, on the contrary, he is too frequently a gainer.

Till the reign of Hen. VIII. there were but two coinages a year for Tin, viz. at Midsummer and Michaelmas, when the Tinnors by petition and proving the inconveniency arising from the long vacation between the latter and the former, obtained the liberty to coin their Tin quarterly by adding Christmas and Lady-day to the foregoing coinages; for which they pay to the duke of Cornwall an acknowledgment (called Post-Groats) of fourpence extra for every hundred of White Tin coined in those quarters. The privileged towns for coinage of Tin were anciently Liskeard, Lostwithiel, Truro, and Helston. For the conveniency of the western Tinnors, soon after the restoration Penzance was also made a coinage town; in which last place, there is every quarter abundantly more Tin coined than in all the towns of Liskeard, Lostwithiel, and Helston put together, for a whole year.

When the Tin is brought to be coined, it is carried into the coinage hall built on purpose to receive it, where the assay master's deputy assays it by cutting off with a chissel and hammer a piece of one of the bottom corners of the block about a pound weight, partly by cutting and partly by breaking, in order to prove the toughness and fineness of the Metal. If it is pure good Tin, the face of the block is stamped with the duchy seal, which stamp is a permit for the owner to sell, and at the same time an assurance that the Tin so marked has been purposely examined and found merchantable. The stamping

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this



this impresson by a hammer, in like manner as was anciently done to render money current, is coining the Tin, and the man who does it is called the Hammer Man.

The arms of Condorus, last earl of Cornwall of British blood, (Temp. W. I.) were Sable 15 Bezants (5,4,3,2,1) in pale Or. Richard, king of the Romans, earl of Cornwall, son to king John, threw these Bezants into a border round the bearing of the earl of Poictou: he bore therefore argent, a Lion Rampant Gules, crowned Or within a bordure garnished with Bezants: and this still continues the duchy seal. Besides this impresson, the Tin bears that also of the particular house where it was smelted, which I have mentioned in my last chapter, in order that if there be any deceit used in the Tin by any foul mixture (making a pye as they call it, by putting hard heads, &c. in the middle, and lading the Tin to cover the cheat, that it may escape the assayers notice, which has formerly happened) their roguery may be the more easily detected. The credulous believe, that by the old Stannary laws, the person convicted of such adulteration and fraudulency was to have three spoonfulls of melted Tin poured down his throat; a punishment that would effectually secure him from a repetition of the same act. Besides the foregoing officers of the coinage, there are numerators to set down the number of blocks coined every quarter, together with the smelting-house numbers, and the weight of each block, all which are carefully registered, that no mistake shall happen, or dispute arise between the revenue officers and the owners of the Tin, or between the latter and the purchasers, the initials of the original proprietors names being likewise stamped on every block.

If we extend our examination to the exportation of Tin, we shall find that the ancient inhabitants had greatly the advantage of us in this particular. The industrious republicans of Africa sought our Tin with an ardour equal to what we discover in fetching gold dust from the shores of that continent; and the coasting voyage they were obliged to perform from their ignorance of the loadstone, was attended with more delays and hazard than has been experienced since in the circumnavigation of the world. But let us turn our eyes to the reverse of this picture: possessed of a numerous and, frequently, starving poor, with the advantage of a harbour, the second in point of size and safety in the whole island, yet where is there a single manufactory of Tin ware among us? The instances have been  
very



very rare also, of a direct exportion of Block or Bar Tin to Holland, Turkey, or even to America: on the contrary it is shipped for the port of London, and double commission and insurance is the necessary consequence; at the same time that those cargoes which are consigned to the Mediterranean or American markets must repass our coasts, and run a risk of being cast on their native shore. There is one consideration more, that I shall beg leave to mention; and the inattention is so great, that, were it not for the poor labourer whose bread depends on the price of his Tin, it would make me divest myself of compassion for every other person concerned either as land-holder or adventurer. The consignments of Tin on commission for foreign markets have fallen, by I know not what infatuation, into the hands of the pewterer in London. His interest in keeping down the price of Block Tin, must infinitely exceed any degree of percentage he could expect on his commission for exportation. By this means he is enabled to dictate to his principals; and fix the price of the commodity to his own standard. It would be wasting time to dwell on this subject. I should gladly have drawn a veil over it, to spare the disgraceful inference that must naturally arise on the bare mention of it: but as all things have an end, so there must be some period to the strongest degree of lethargy; and some efforts a few years back made me hope, the gentlemen of the Mining districts would not have wanted any shaking to awaken them. But these efforts, from the little attention paid to the real state of the Tin trade, will hardly be sufficient to convince the unprejudiced, that they were fully awake.

T A B L E S,



# T A B L E S,

Shewing what Quantity of White Tin must be delivered by the Smelter for any Quantity of Black Tin, from 4 lb of White, for 20 lb of Black, to  $13\frac{3}{4}$  lb of White for 20 lb of Black.

At 4 for 20

| Bl. Tin | White Tin |    | Bl. Tin | White Tin |   |    |    |
|---------|-----------|----|---------|-----------|---|----|----|
| lb      | lb        | 20 | C.      | C.        | Q | lb | 20 |
| 1       | —         | 4  | 1       | —         | — | 22 | 8  |
| 2       | —         | 8  | 2       | —         | 1 | 16 | 16 |
| 3       | —         | 12 | 3       | —         | 2 | 11 | 4  |
| 4       | —         | 16 | 4       | —         | 3 | 5  | 12 |
| 5       | 1         | —  | 5       | 1         | — | —  | —  |
| 6       | 1         | 4  | 6       | 1         | — | 22 | 8  |
| 7       | 1         | 8  | 7       | 1         | 1 | 16 | 16 |
| 8       | 1         | 12 | 8       | 1         | 2 | 11 | 4  |
| 9       | 1         | 16 | 9       | 1         | 3 | 5  | 12 |
| 10      | 2         | —  | 10      | 2         | — | —  | —  |
| 11      | 2         | 4  | 20      | 4         | — | —  | —  |
| 12      | 2         | 8  | 30      | 6         | — | —  | —  |
| 13      | 2         | 12 | 40      | 8         | — | —  | —  |
| 14      | 2         | 16 | 50      | 10        | — | —  | —  |
|         |           |    | 60      | 12        | — | —  | —  |
| 28      | 5         | 12 | 70      | 14        | — | —  | —  |
| 56      | 11        | 4  | 80      | 16        | — | —  | —  |
| 84      | 16        | 16 | 90      | 18        | — | —  | —  |
|         |           |    | 100     | 20        | — | —  | —  |
|         |           |    | 200     | 40        | — | —  | —  |

At  $4\frac{1}{2}$  for 20

| Bl. Tin | White Tin |                 | Bl. Tin | White Tin |   |    |    |
|---------|-----------|-----------------|---------|-----------|---|----|----|
| lb      | lb        | 20              | C.      | C.        | Q | lb | 20 |
| 1       | —         | $4\frac{1}{2}$  | 1       | —         | — | 25 | 4  |
| 2       | —         | 9               | 2       | —         | 1 | 22 | 8  |
| 3       | —         | $13\frac{1}{2}$ | 3       | —         | 2 | 19 | 12 |
| 4       | —         | 18              | 4       | —         | 3 | 16 | 16 |
| 5       | 1         | $2\frac{1}{2}$  | 5       | 1         | — | 14 | —  |
| 6       | 1         | 7               | 6       | 1         | 1 | 11 | 4  |
| 7       | 1         | $11\frac{1}{2}$ | 7       | 1         | 2 | 8  | 8  |
| 8       | 1         | 16              | 8       | 1         | 3 | 5  | 12 |
| 9       | 2         | $\frac{1}{2}$   | 9       | 2         | — | 2  | 16 |
| 10      | 2         | 5               | 10      | 2         | 1 | —  | —  |
| 11      | 2         | $9\frac{1}{2}$  | 20      | 4         | 2 | —  | —  |
| 12      | 2         | 14              | 30      | 6         | 3 | —  | —  |
| 13      | 2         | $18\frac{1}{2}$ | 40      | 8         | — | —  | —  |
| 14      | 3         | 3               | 50      | 11        | 1 | —  | —  |
|         |           |                 | 60      | 13        | 2 | —  | —  |
| 28      | 6         | 6               | 70      | 15        | 3 | —  | —  |
| 56      | 12        | 12              | 80      | 18        | — | —  | —  |
| 84      | 18        | 18              | 90      | 20        | 1 | —  | —  |
|         |           |                 | 100     | 22        | 2 | —  | —  |
|         |           |                 | 200     | 45        | — | —  | —  |

At  $4\frac{1}{4}$  for 20

| Bl. Tin | White Tin |                 | Bl. Tin | White Tin |   |    |    |
|---------|-----------|-----------------|---------|-----------|---|----|----|
| lb      | lb        | 20              | C.      | C.        | Q | lb | 20 |
| 1       | —         | $4\frac{1}{4}$  | 1       | —         | — | 23 | 16 |
| 2       | —         | $8\frac{1}{2}$  | 2       | —         | 1 | 19 | 12 |
| 3       | —         | $12\frac{3}{4}$ | 3       | —         | 2 | 15 | 8  |
| 4       | —         | 17              | 4       | —         | 3 | 11 | 4  |
| 5       | 1         | $1\frac{1}{4}$  | 5       | 1         | — | 7  | —  |
| 6       | 1         | $5\frac{1}{2}$  | 6       | 1         | 1 | 2  | 16 |
| 7       | 1         | $9\frac{3}{4}$  | 7       | 1         | 1 | 26 | 12 |
| 8       | 1         | 14              | 8       | 1         | 2 | 22 | 8  |
| 9       | 1         | $18\frac{1}{4}$ | 9       | 1         | 3 | 18 | 4  |
| 10      | 2         | $2\frac{1}{2}$  | 10      | 2         | — | 14 | —  |
| 11      | 2         | $6\frac{3}{4}$  | 20      | 4         | 1 | —  | —  |
| 12      | 2         | 11              | 30      | 6         | 1 | 14 | —  |
| 13      | 2         | $15\frac{1}{4}$ | 40      | 8         | 2 | —  | —  |
| 14      | 2         | $19\frac{1}{2}$ | 50      | 10        | 2 | 14 | —  |
|         |           |                 | 60      | 12        | 3 | —  | —  |
| 28      | 5         | 19              | 70      | 14        | 3 | 14 | —  |
| 56      | 11        | 18              | 80      | 17        | — | —  | —  |
| 84      | 17        | 17              | 90      | 19        | — | 14 | —  |
|         |           |                 | 100     | 21        | 1 | —  | —  |
|         |           |                 | 200     | 42        | 2 | —  | —  |

At  $4\frac{3}{4}$  for 20

| Bl. Tin | White Tin |                 | Bl. Tin | White Tin |   |    |    |
|---------|-----------|-----------------|---------|-----------|---|----|----|
| lb      | lb        | 20              | C.      | C.        | Q | lb | 20 |
| 1       | —         | $4\frac{3}{4}$  | 1       | —         | — | 26 | 12 |
| 2       | —         | $9\frac{1}{2}$  | 2       | —         | 1 | 25 | 4  |
| 3       | —         | $14\frac{1}{4}$ | 3       | —         | 2 | 23 | 16 |
| 4       | —         | 19              | 4       | —         | 3 | 22 | 8  |
| 5       | 1         | $3\frac{3}{4}$  | 5       | 1         | — | 21 | —  |
| 6       | 1         | $8\frac{1}{2}$  | 6       | 1         | 1 | 19 | 12 |
| 7       | 1         | $13\frac{1}{4}$ | 7       | 1         | 2 | 18 | 4  |
| 8       | 1         | 18              | 8       | 1         | 3 | 16 | 16 |
| 9       | 2         | $2\frac{3}{4}$  | 9       | 2         | — | 15 | 8  |
| 10      | 2         | $7\frac{1}{2}$  | 10      | 2         | 1 | 14 | —  |
| 11      | 2         | $12\frac{1}{4}$ | 20      | 4         | 3 | —  | —  |
| 12      | 2         | 17              | 30      | 7         | — | 14 | —  |
| 13      | 3         | $1\frac{3}{4}$  | 40      | 9         | 2 | —  | —  |
| 14      | 3         | $6\frac{1}{2}$  | 50      | 11        | 3 | 14 | —  |
|         |           |                 | 60      | 14        | 1 | —  | —  |
| 28      | 6         | 13              | 70      | 16        | 2 | 14 | —  |
| 56      | 13        | 6               | 80      | 19        | — | —  | —  |
| 84      | 19        | 19              | 90      | 21        | 1 | 14 | —  |
|         |           |                 | 100     | 23        | 3 | —  | —  |
|         |           |                 | 200     | 47        | 2 | —  | —  |



At 5 for 20

| Bl. Tin | White Tin |    | Bl. Tin | White Tin |   |    |    |
|---------|-----------|----|---------|-----------|---|----|----|
| lb      | lb        | 20 | C.      | C.        | Q | lb | 20 |
| 1       | —         | 5  | 1       | —         | 1 | —  | —  |
| 2       | —         | 10 | 2       | —         | 2 | —  | —  |
| 3       | —         | 15 | 3       | —         | 3 | —  | —  |
| 4       | 1         | —  | 4       | 1         | — | —  | —  |
| 5       | 1         | 5  | 5       | 1         | 1 | —  | —  |
| 6       | 1         | 10 | 6       | 1         | 2 | —  | —  |
| 7       | 1         | 15 | 7       | 1         | 3 | —  | —  |
| 8       | 2         | —  | 8       | 2         | — | —  | —  |
| 9       | 2         | 5  | 9       | 2         | 1 | —  | —  |
| 10      | 2         | 10 | 10      | 2         | 2 | —  | —  |
| 11      | 2         | 15 | 20      | 5         | — | —  | —  |
| 12      | 3         | —  | 30      | 7         | 2 | —  | —  |
| 13      | 3         | 5  | 40      | 10        | — | —  | —  |
| 14      | 3         | 10 | 50      | 12        | 2 | —  | —  |
|         |           |    | 60      | 15        | — | —  | —  |
| 28      | 7         | —  | 70      | 17        | 2 | —  | —  |
| 56      | 14        | —  | 80      | 20        | — | —  | —  |
| 84      | 21        | —  | 90      | 22        | 2 | —  | —  |
|         |           |    | 100     | 25        | — | —  | —  |
|         |           |    | 200     | 50        | — | —  | —  |

At  $5\frac{1}{2}$  for 20

| Bl. Tin | White Tin |                 | Bl. Tin | White Tin |   |    |    |
|---------|-----------|-----------------|---------|-----------|---|----|----|
| lb      | lb        | 20              | C.      | C.        | Q | lb | 20 |
| 1       | —         | $5\frac{1}{2}$  | 1       | —         | 1 | 2  | 16 |
| 2       | —         | 11              | 2       | —         | 2 | 5  | 12 |
| 3       | —         | $16\frac{1}{2}$ | 3       | —         | 3 | 8  | 8  |
| 4       | 1         | 2               | 4       | 1         | — | 11 | 4  |
| 5       | 1         | $7\frac{1}{2}$  | 5       | 1         | 1 | 14 | —  |
| 6       | 1         | 13              | 6       | 1         | 2 | 16 | 16 |
| 7       | 1         | $18\frac{1}{2}$ | 7       | 1         | 3 | 19 | 12 |
| 8       | 2         | 4               | 8       | 2         | — | 22 | 8  |
| 9       | 2         | $9\frac{1}{2}$  | 9       | 2         | 1 | 25 | 4  |
| 10      | 2         | 15              | 10      | 2         | 3 | —  | —  |
| 11      | 3         | $\frac{1}{2}$   | 20      | 5         | 2 | —  | —  |
| 12      | 3         | 6               | 30      | 8         | 1 | —  | —  |
| 13      | 3         | $11\frac{1}{2}$ | 40      | 11        | — | —  | —  |
| 14      | 3         | 17              | 50      | 13        | 3 | —  | —  |
|         |           |                 | 60      | 16        | 2 | —  | —  |
| 28      | 7         | 14              | 70      | 19        | 1 | —  | —  |
| 56      | 15        | 8               | 80      | 22        | — | —  | —  |
| 84      | 23        | 2               | 90      | 24        | 3 | —  | —  |
|         |           |                 | 100     | 27        | 2 | —  | —  |
|         |           |                 | 200     | 55        | — | —  | —  |

At  $5\frac{1}{4}$  for 20

| Bl. Tin | White Tin |                 | Bl. Tin | White Tin |   |    |    |
|---------|-----------|-----------------|---------|-----------|---|----|----|
| lb      | lb        | 20              | C.      | C.        | Q | lb | 20 |
| 1       | —         | $5\frac{1}{4}$  | 1       | —         | 1 | 1  | 8  |
| 2       | —         | $10\frac{1}{2}$ | 2       | —         | 2 | 2  | 16 |
| 3       | —         | $15\frac{3}{4}$ | 3       | —         | 3 | 4  | 4  |
| 4       | 1         | 1               | 4       | 1         | — | 5  | 12 |
| 5       | 1         | $6\frac{1}{4}$  | 5       | 1         | 1 | 7  | —  |
| 6       | 1         | $11\frac{1}{2}$ | 6       | 1         | 2 | 8  | 8  |
| 7       | 1         | $16\frac{3}{4}$ | 7       | 1         | 3 | 9  | 16 |
| 8       | 2         | 2               | 8       | 2         | — | 11 | 4  |
| 9       | 2         | $7\frac{1}{4}$  | 9       | 2         | 1 | 12 | 12 |
| 10      | 2         | $12\frac{1}{2}$ | 10      | 2         | 2 | 14 | —  |
| 11      | 2         | $17\frac{3}{4}$ | 20      | 5         | 1 | —  | —  |
| 12      | 3         | 3               | 30      | 7         | 3 | 14 | —  |
| 13      | 3         | $8\frac{1}{4}$  | 40      | 10        | 2 | —  | —  |
| 14      | 3         | $13\frac{1}{2}$ | 50      | 13        | — | 14 | —  |
|         |           |                 | 60      | 15        | 3 | —  | —  |
| 28      | 7         | 7               | 70      | 18        | 1 | 14 | —  |
| 56      | 14        | 14              | 80      | 21        | — | —  | —  |
| 84      | 22        | 1               | 90      | 23        | 2 | 14 | —  |
|         |           |                 | 100     | 26        | 1 | —  | —  |
|         |           |                 | 200     | 52        | 2 | —  | —  |

At  $5\frac{3}{4}$  for 20

| Bl. Tin | White Tin |                 | Bl. Tin | White Tin |   |    |    |
|---------|-----------|-----------------|---------|-----------|---|----|----|
| lb      | lb        | 20              | C.      | C.        | Q | lb | 20 |
| 1       | —         | $5\frac{3}{4}$  | 1       | —         | 1 | 4  | 4  |
| 2       | —         | $11\frac{1}{2}$ | 2       | —         | 2 | 8  | 8  |
| 3       | —         | $17\frac{1}{4}$ | 3       | —         | 3 | 12 | 12 |
| 4       | 1         | 3               | 4       | 1         | — | 16 | 16 |
| 5       | 1         | $8\frac{3}{4}$  | 5       | 1         | 1 | 21 | —  |
| 6       | 1         | $14\frac{1}{2}$ | 6       | 1         | 2 | 25 | 4  |
| 7       | 2         | $\frac{1}{4}$   | 7       | 2         | — | 1  | 8  |
| 8       | 2         | 6               | 8       | 2         | 1 | 5  | 12 |
| 9       | 2         | $11\frac{3}{4}$ | 9       | 2         | 2 | 9  | 16 |
| 10      | 2         | $17\frac{1}{2}$ | 10      | 2         | 3 | 14 | —  |
| 11      | 3         | $3\frac{1}{4}$  | 20      | 5         | 3 | —  | —  |
| 12      | 3         | 9               | 30      | 8         | 2 | 14 | —  |
| 13      | 3         | $14\frac{3}{4}$ | 40      | 11        | 2 | —  | —  |
| 14      | 4         | $\frac{1}{2}$   | 50      | 14        | 1 | 14 | —  |
|         |           |                 | 60      | 17        | 1 | —  | —  |
| 28      | 8         | 1               | 70      | 20        | — | 14 | —  |
| 56      | 16        | 2               | 80      | 23        | — | —  | —  |
| 84      | 24        | 3               | 90      | 25        | 3 | 14 | —  |
|         |           |                 | 100     | 28        | 3 | —  | —  |
|         |           |                 | 200     | 57        | 2 | —  | —  |



At 6 for 20

| Bl.<br>Tin | White Tin |    | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|----|------------|-----------|---|----|----|
| lb         | lb        | 20 | C.         | C.        | Q | lb | 20 |
| 1          | —         | 6  | 1          | —         | 1 | 5  | 12 |
| 2          | —         | 12 | 2          | —         | 2 | 11 | 4  |
| 3          | —         | 18 | 3          | —         | 3 | 16 | 16 |
| 4          | 1         | 4  | 4          | 1         | — | 22 | 8  |
| 5          | 1         | 10 | 5          | 1         | 2 | —  | —  |
| 6          | 1         | 16 | 6          | 1         | 3 | 5  | 12 |
| 7          | 2         | 2  | 7          | 2         | — | 11 | 4  |
| 8          | 2         | 8  | 8          | 2         | 1 | 16 | 16 |
| 9          | 2         | 14 | 9          | 2         | 2 | 22 | 8  |
| 10         | 3         | —  | 10         | 3         | — | —  | —  |
| 11         | 3         | 6  | 20         | 6         | — | —  | —  |
| 12         | 3         | 12 | 30         | 9         | — | —  | —  |
| 13         | 3         | 18 | 40         | 12        | — | —  | —  |
| 14         | 4         | 4  | 50         | 15        | — | —  | —  |
|            |           |    | 60         | 18        | — | —  | —  |
| 28         | 8         | 8  | 70         | 21        | — | —  | —  |
| 56         | 16        | 16 | 80         | 24        | — | —  | —  |
| 84         | 25        | 4  | 90         | 27        | — | —  | —  |
|            |           |    | 100        | 30        | — | —  | —  |
|            |           |    | 200        | 60        | — | —  | —  |

At  $6\frac{1}{2}$  for 20

| Bl.<br>Tin | White Tin |                 | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|-----------------|------------|-----------|---|----|----|
| lb         | lb        | 20              | C.         | C.        | Q | lb | 20 |
| 1          | —         | $6\frac{1}{2}$  | 1          | —         | 1 | 8  | 8  |
| 2          | —         | 13              | 2          | —         | 2 | 16 | 16 |
| 3          | —         | $19\frac{1}{2}$ | 3          | —         | 3 | 25 | 4  |
| 4          | 1         | 6               | 4          | 1         | 1 | 5  | 12 |
| 5          | 1         | $12\frac{1}{2}$ | 5          | 1         | 2 | 14 | —  |
| 6          | 1         | 19              | 6          | 1         | 3 | 22 | 8  |
| 7          | 2         | $5\frac{1}{2}$  | 7          | 2         | 1 | 2  | 16 |
| 8          | 2         | 12              | 8          | 2         | 2 | 11 | 4  |
| 9          | 2         | $18\frac{1}{2}$ | 9          | 2         | 3 | 19 | 12 |
| 10         | 3         | 5               | 10         | 3         | 1 | —  | —  |
| 11         | 3         | $11\frac{1}{2}$ | 20         | 6         | 2 | —  | —  |
| 12         | 3         | 18              | 30         | 9         | 3 | —  | —  |
| 13         | 4         | $4\frac{1}{2}$  | 40         | 13        | — | —  | —  |
| 14         | 4         | 11              | 50         | 16        | 1 | —  | —  |
|            |           |                 | 60         | 19        | 2 | —  | —  |
| 28         | 9         | 2               | 70         | 22        | 3 | —  | —  |
| 56         | 18        | 4               | 80         | 26        | — | —  | —  |
| 84         | 27        | 6               | 90         | 29        | 1 | —  | —  |
|            |           |                 | 100        | 32        | 2 | —  | —  |
|            |           |                 | 200        | 65        | — | —  | —  |

At  $6\frac{1}{4}$  for 20

| Bl.<br>Tin | White Tin |                 | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|-----------------|------------|-----------|---|----|----|
| lb         | lb        | 20              | C.         | C.        | Q | lb | 20 |
| 1          | —         | $6\frac{1}{4}$  | 1          | —         | 1 | 7  | —  |
| 2          | —         | $12\frac{1}{2}$ | 2          | —         | 2 | 14 | —  |
| 3          | —         | $18\frac{3}{4}$ | 3          | —         | 3 | 21 | —  |
| 4          | 1         | 5               | 4          | 1         | 1 | —  | —  |
| 5          | 1         | $11\frac{1}{4}$ | 5          | 1         | 2 | 7  | —  |
| 6          | 1         | $17\frac{1}{2}$ | 6          | 1         | 3 | 14 | —  |
| 7          | 2         | $3\frac{1}{4}$  | 7          | 2         | — | 21 | —  |
| 8          | 2         | 10              | 8          | 2         | 2 | —  | —  |
| 9          | 2         | $16\frac{1}{4}$ | 9          | 2         | 3 | 7  | —  |
| 10         | 3         | $2\frac{1}{2}$  | 10         | 3         | — | 14 | —  |
| 11         | 3         | $8\frac{3}{4}$  | 20         | 6         | 1 | —  | —  |
| 12         | 3         | 15              | 30         | 9         | 1 | 14 | —  |
| 13         | 4         | $1\frac{1}{4}$  | 40         | 12        | 2 | —  | —  |
| 14         | 4         | $7\frac{1}{2}$  | 50         | 15        | 2 | 14 | —  |
|            |           |                 | 60         | 18        | 3 | —  | —  |
| 28         | 8         | 15              | 70         | 21        | 3 | 14 | —  |
| 56         | 17        | 10              | 80         | 25        | — | —  | —  |
| 84         | 26        | 5               | 90         | 28        | — | 14 | —  |
|            |           |                 | 100        | 31        | 1 | —  | —  |
|            |           |                 | 200        | 62        | 2 | —  | —  |

At  $6\frac{3}{4}$  for 20

| Bl.<br>Tin | White Tin |                 | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|-----------------|------------|-----------|---|----|----|
| lb         | lb        | 20              | C.         | C.        | Q | lb | 20 |
| 1          | —         | $6\frac{3}{4}$  | 1          | —         | 1 | 9  | 16 |
| 2          | —         | $13\frac{1}{2}$ | 2          | —         | 2 | 19 | 12 |
| 3          | 1         | $\frac{1}{4}$   | 3          | 1         | — | 1  | 8  |
| 4          | 1         | 7               | 4          | 1         | 1 | 11 | 4  |
| 5          | 1         | $13\frac{1}{4}$ | 5          | 1         | 2 | 21 | —  |
| 6          | 2         | $\frac{1}{2}$   | 6          | 2         | — | 2  | 16 |
| 7          | 2         | $7\frac{1}{4}$  | 7          | 2         | 1 | 12 | 12 |
| 8          | 2         | 14              | 8          | 2         | 2 | 22 | 8  |
| 9          | 3         | $\frac{3}{4}$   | 9          | 3         | — | 4  | 4  |
| 10         | 3         | $7\frac{1}{2}$  | 10         | 3         | 1 | 14 | —  |
| 11         | 3         | $14\frac{1}{4}$ | 20         | 6         | 3 | —  | —  |
| 12         | 4         | 1               | 30         | 10        | — | 14 | —  |
| 13         | 4         | $7\frac{3}{4}$  | 40         | 13        | 2 | —  | —  |
| 14         | 4         | $14\frac{1}{2}$ | 50         | 16        | 3 | 14 | —  |
|            |           |                 | 60         | 20        | 1 | —  | —  |
| 28         | 9         | 9               | 70         | 23        | 2 | 14 | —  |
| 56         | 18        | 18              | 80         | 27        | — | —  | —  |
| 84         | 28        | 7               | 90         | 30        | 1 | 14 | —  |
|            |           |                 | 100        | 33        | 3 | —  | —  |
|            |           |                 | 200        | 67        | 2 | —  | —  |



At 7 for 20

| Bl.<br>Tin | White Tin |    | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|----|------------|-----------|---|----|----|
| lb         | lb        | 20 | C.         | C.        | Q | lb | 20 |
| 1          | —         | 7  | 1          | —         | 1 | 11 | 4  |
| 2          | —         | 14 | 2          | —         | 2 | 22 | 8  |
| 3          | 1         | 1  | 3          | 1         | — | 5  | 12 |
| 4          | 1         | 8  | 4          | 1         | 1 | 16 | 16 |
| 5          | 1         | 15 | 5          | 1         | 3 | —  | —  |
| 6          | 2         | 2  | 6          | 2         | — | 11 | 4  |
| 7          | 2         | 9  | 7          | 2         | 1 | 22 | 8  |
| 8          | 2         | 16 | 8          | 2         | 3 | 5  | 12 |
| 9          | 3         | 3  | 9          | 3         | — | 16 | 16 |
| 10         | 3         | 10 | 10         | 3         | 2 | —  | —  |
| 11         | 3         | 17 | 20         | 7         | — | —  | —  |
| 12         | 4         | 4  | 30         | 10        | 2 | —  | —  |
| 13         | 4         | 11 | 40         | 14        | — | —  | —  |
| 14         | 4         | 18 | 50         | 17        | 2 | —  | —  |
|            |           |    | 60         | 21        | — | —  | —  |
| 28         | 9         | 16 | 70         | 24        | 2 | —  | —  |
| 56         | 19        | 12 | 80         | 28        | — | —  | —  |
| 84         | 29        | 8  | 90         | 31        | 2 | —  | —  |
|            |           |    | 100        | 35        | — | —  | —  |
|            |           |    | 200        | 70        | — | —  | —  |

At  $7\frac{1}{2}$  for 20

| Bl.<br>Tin | White Tin |                 | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|-----------------|------------|-----------|---|----|----|
| lb         | lb        | 20              | C.         | C.        | Q | lb | 20 |
| 1          | —         | $7\frac{1}{2}$  | 1          | —         | 1 | 14 | —  |
| 2          | —         | 15              | 2          | —         | 3 | —  | —  |
| 3          | 1         | $2\frac{1}{2}$  | 3          | 1         | — | 14 | —  |
| 4          | 1         | 10              | 4          | 1         | 2 | —  | —  |
| 5          | 1         | $17\frac{1}{2}$ | 5          | 1         | 3 | 14 | —  |
| 6          | 2         | 5               | 6          | 2         | 1 | —  | —  |
| 7          | 2         | $12\frac{1}{2}$ | 7          | 2         | 2 | 14 | —  |
| 8          | 3         | —               | 8          | 3         | — | —  | —  |
| 9          | 3         | $7\frac{1}{2}$  | 9          | 3         | 1 | 14 | —  |
| 10         | 3         | 15              | 10         | 3         | 3 | —  | —  |
| 11         | 4         | $2\frac{1}{2}$  | 20         | 7         | 2 | —  | —  |
| 12         | 4         | 10              | 30         | 11        | 1 | —  | —  |
| 13         | 4         | $17\frac{1}{2}$ | 40         | 15        | — | —  | —  |
| 14         | 5         | 5               | 50         | 18        | 3 | —  | —  |
|            |           |                 | 60         | 22        | 2 | —  | —  |
| 28         | 10        | 10              | 70         | 26        | 1 | —  | —  |
| 56         | 21        | —               | 80         | 30        | — | —  | —  |
| 84         | 31        | 10              | 90         | 33        | 3 | —  | —  |
|            |           |                 | 100        | 37        | 2 | —  | —  |
|            |           |                 | 200        | 75        | — | —  | —  |

At  $7\frac{1}{4}$  for 20

| Bl.<br>Tin | White Tin |                 | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|-----------------|------------|-----------|---|----|----|
| lb         | lb        | 20              | C.         | C.        | Q | lb | 20 |
| 1          | —         | $7\frac{1}{4}$  | 1          | —         | 1 | 12 | 12 |
| 2          | —         | $14\frac{1}{2}$ | 2          | —         | 2 | 25 | 4  |
| 3          | 1         | $1\frac{3}{4}$  | 3          | 1         | — | 9  | 16 |
| 4          | 1         | 9               | 4          | 1         | 1 | 24 | 8  |
| 5          | 1         | $16\frac{1}{4}$ | 5          | 1         | 3 | 7  | —  |
| 6          | 2         | $3\frac{1}{2}$  | 6          | 2         | — | 19 | 12 |
| 7          | 2         | $10\frac{3}{4}$ | 7          | 2         | 2 | 4  | 4  |
| 8          | 2         | 18              | 8          | 2         | 3 | 16 | 16 |
| 9          | 3         | $5\frac{1}{4}$  | 9          | 2         | 1 | 1  | 8  |
| 10         | 3         | $12\frac{1}{2}$ | 10         | 3         | 2 | 14 | —  |
| 11         | 3         | $19\frac{1}{4}$ | 20         | 7         | 1 | —  | —  |
| 12         | 4         | 7               | 30         | 10        | 3 | 14 | —  |
| 13         | 4         | $14\frac{1}{4}$ | 40         | 14        | 2 | —  | —  |
| 14         | 5         | $1\frac{1}{2}$  | 50         | 18        | — | 14 | —  |
|            |           |                 | 60         | 21        | 3 | —  | —  |
| 28         | 10        | 3               | 70         | 25        | 1 | 14 | —  |
| 56         | 20        | 6               | 80         | 29        | — | —  | —  |
| 84         | 30        | 9               | 90         | 32        | 2 | 14 | —  |
|            |           |                 | 100        | 36        | 1 | —  | —  |
|            |           |                 | 200        | 72        | 2 | —  | —  |

At  $7\frac{1}{2}$  for 20

| Bl.<br>Tin | White Tin |                 | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|-----------------|------------|-----------|---|----|----|
| lb         | lb        | 20              | C.         | C.        | Q | lb | 20 |
| 1          | —         | $7\frac{1}{2}$  | 1          | —         | 1 | 15 | 8  |
| 2          | —         | $15\frac{1}{2}$ | 2          | —         | 3 | 2  | 16 |
| 3          | 1         | $3\frac{1}{4}$  | 3          | 1         | — | 18 | 4  |
| 4          | 1         | 11              | 4          | 1         | 2 | 5  | 12 |
| 5          | 1         | $18\frac{1}{4}$ | 5          | 1         | 3 | 21 | —  |
| 6          | 2         | $6\frac{1}{2}$  | 6          | 2         | 1 | 8  | 8  |
| 7          | 2         | $14\frac{1}{4}$ | 7          | 2         | 2 | 23 | 16 |
| 8          | 3         | 2               | 8          | 3         | — | 11 | 4  |
| 9          | 3         | $9\frac{3}{4}$  | 9          | 3         | 1 | 26 | 12 |
| 10         | 3         | $17\frac{1}{2}$ | 10         | 3         | 3 | 14 | —  |
| 11         | 4         | $5\frac{1}{4}$  | 20         | 7         | 3 | —  | —  |
| 12         | 4         | 13              | 30         | 11        | 2 | 14 | —  |
| 13         | 5         | $\frac{3}{4}$   | 40         | 15        | 2 | —  | —  |
| 14         | 5         | $8\frac{1}{2}$  | 50         | 19        | 1 | 14 | —  |
|            |           |                 | 60         | 23        | 1 | —  | —  |
| 28         | 10        | 17              | 70         | 27        | — | 14 | —  |
| 56         | 21        | 14              | 80         | 31        | — | —  | —  |
| 84         | 32        | 11              | 90         | 34        | 3 | 14 | —  |
|            |           |                 | 100        | 38        | 3 | —  | —  |
|            |           |                 | 200        | 77        | 2 | —  | —  |



At 8 for 20

| Bl.<br>Tin | White Tin |    | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|----|------------|-----------|---|----|----|
| lb         | lb        | 20 | C.         | C.        | Q | lb | 20 |
| 1          | —         | 8  | 1          | —         | 1 | 16 | 16 |
| 2          | —         | 16 | 2          | —         | 3 | 5  | 12 |
| 3          | 1         | 4  | 3          | 1         | — | 22 | 8  |
| 4          | 1         | 12 | 4          | 1         | 2 | 11 | 4  |
| 5          | 2         | —  | 5          | 2         | — | —  | —  |
| 6          | 2         | 8  | 6          | 2         | 1 | 16 | 16 |
| 7          | 2         | 16 | 7          | 2         | 3 | 5  | 12 |
| 8          | 3         | 4  | 8          | 3         | — | 22 | 8  |
| 9          | 3         | 12 | 9          | 3         | 2 | 11 | 4  |
| 10         | 4         | —  | 10         | 4         | — | —  | —  |
| 11         | 4         | 8  | 20         | 8         | — | —  | —  |
| 12         | 4         | 16 | 30         | 12        | — | —  | —  |
| 13         | 5         | 4  | 40         | 16        | — | —  | —  |
| 14         | 5         | 12 | 50         | 20        | — | —  | —  |
|            |           |    | 60         | 24        | — | —  | —  |
| 28         | 11        | 4  | 70         | 28        | — | —  | —  |
| 56         | 22        | 8  | 80         | 32        | — | —  | —  |
| 84         | 33        | 12 | 90         | 36        | — | —  | —  |
|            |           |    | 100        | 40        | — | —  | —  |
|            |           |    | 200        | 80        | — | —  | —  |

At  $8\frac{1}{2}$  for 20

| Bl.<br>Tin | White Tin |                 | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|-----------------|------------|-----------|---|----|----|
| lb         | lb        | 20              | C.         | C.        | Q | lb | 20 |
| 1          | —         | $8\frac{1}{2}$  | 1          | —         | 1 | 19 | 12 |
| 2          | —         | 17              | 2          | —         | 3 | 11 | 4  |
| 3          | 1         | $5\frac{1}{2}$  | 3          | 1         | 1 | 2  | 16 |
| 4          | 1         | 14              | 4          | 1         | 2 | 22 | 8  |
| 5          | 2         | $2\frac{1}{2}$  | 5          | 2         | — | 14 | —  |
| 6          | 2         | 11              | 6          | 2         | 2 | 5  | 12 |
| 7          | 2         | $19\frac{1}{2}$ | 7          | 2         | 3 | 25 | 4  |
| 8          | 3         | 8               | 8          | 3         | 1 | 16 | 16 |
| 9          | 3         | $16\frac{1}{2}$ | 9          | 3         | 3 | 8  | 8  |
| 10         | 4         | 5               | 10         | 4         | 1 | —  | —  |
| 11         | 4         | $13\frac{1}{2}$ | 20         | 8         | 2 | —  | —  |
| 12         | 5         | 2               | 30         | 12        | 3 | —  | —  |
| 13         | 5         | $10\frac{1}{2}$ | 40         | 17        | — | —  | —  |
| 14         | 5         | 19              | 50         | 21        | 1 | —  | —  |
|            |           |                 | 60         | 25        | 2 | —  | —  |
| 28         | 11        | 18              | 70         | 29        | 3 | —  | —  |
| 56         | 23        | 16              | 80         | 34        | — | —  | —  |
| 84         | 35        | 14              | 90         | 38        | 1 | —  | —  |
|            |           |                 | 100        | 42        | 2 | —  | —  |
|            |           |                 | 200        | 85        | — | —  | —  |

At  $8\frac{1}{4}$  for 20

| Bl.<br>Tin | White Tin |                 | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|-----------------|------------|-----------|---|----|----|
| lb         | lb        | 20              | C.         | C.        | Q | lb | 20 |
| 1          | —         | $8\frac{1}{4}$  | 1          | —         | 1 | 18 | 4  |
| 2          | —         | $16\frac{1}{2}$ | 2          | —         | 3 | 8  | 8  |
| 3          | 1         | $4\frac{3}{4}$  | 3          | 1         | — | 26 | 12 |
| 4          | 1         | 13              | 4          | 1         | 2 | 16 | 16 |
| 5          | 2         | $1\frac{1}{4}$  | 5          | 2         | — | 7  | —  |
| 6          | 2         | $9\frac{1}{2}$  | 6          | 2         | 1 | 25 | 4  |
| 7          | 2         | $17\frac{3}{4}$ | 7          | 2         | 3 | 15 | 8  |
| 8          | 3         | 6               | 8          | 3         | 1 | 5  | 12 |
| 9          | 3         | $14\frac{1}{4}$ | 9          | 3         | 2 | 23 | 16 |
| 10         | 4         | $2\frac{1}{2}$  | 10         | 4         | — | 14 | —  |
| 11         | 4         | $10\frac{3}{4}$ | 20         | 8         | 1 | —  | —  |
| 12         | 4         | 19              | 30         | 12        | 1 | 14 | —  |
| 13         | 5         | $7\frac{1}{4}$  | 40         | 16        | 2 | —  | —  |
| 14         | 5         | $15\frac{1}{2}$ | 50         | 20        | 2 | 14 | —  |
|            |           |                 | 60         | 24        | 3 | —  | —  |
| 28         | 11        | 11              | 70         | 28        | 3 | 14 | —  |
| 56         | 23        | 2               | 80         | 33        | — | —  | —  |
| 84         | 34        | 13              | 90         | 37        | — | 14 | —  |
|            |           |                 | 100        | 41        | 1 | —  | —  |
|            |           |                 | 200        | 82        | 2 | —  | —  |

At  $8\frac{1}{2}$  for 20

| Bl.<br>Tin | White Tin |                 | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|-----------------|------------|-----------|---|----|----|
| lb         | lb        | 20              | C.         | C.        | Q | lb | 20 |
| 1          | —         | $8\frac{1}{2}$  | 1          | —         | 1 | 21 | —  |
| 2          | —         | $17\frac{1}{2}$ | 2          | —         | 3 | 14 | —  |
| 3          | 1         | $6\frac{1}{4}$  | 3          | 1         | 1 | 7  | —  |
| 4          | 1         | 15              | 4          | 1         | 3 | —  | —  |
| 5          | 2         | $3\frac{3}{4}$  | 5          | 2         | — | 21 | —  |
| 6          | 2         | $12\frac{1}{2}$ | 6          | 2         | 2 | 14 | —  |
| 7          | 3         | $1\frac{1}{4}$  | 7          | 3         | — | 7  | —  |
| 8          | 3         | 10              | 8          | 3         | 2 | —  | —  |
| 9          | 3         | $18\frac{3}{4}$ | 9          | 3         | 3 | 21 | —  |
| 10         | 4         | $7\frac{1}{2}$  | 10         | 4         | 1 | 14 | —  |
| 11         | 4         | $16\frac{1}{4}$ | 20         | 8         | 3 | —  | —  |
| 12         | 5         | 5               | 30         | 13        | — | 14 | —  |
| 13         | 5         | $13\frac{3}{4}$ | 40         | 17        | 2 | —  | —  |
| 14         | 6         | $2\frac{1}{2}$  | 50         | 21        | 3 | 14 | —  |
|            |           |                 | 60         | 26        | 1 | —  | —  |
| 28         | 12        | 5               | 70         | 30        | 2 | 14 | —  |
| 56         | 24        | 10              | 80         | 35        | — | —  | —  |
| 84         | 36        | 15              | 90         | 39        | 1 | 14 | —  |
|            |           |                 | 100        | 43        | 3 | —  | —  |
|            |           |                 | 200        | 87        | 2 | —  | —  |



At 9 for 20

| Bl. Tin | White Tin |    | Bl. Tin | White Tin |   |    |    |
|---------|-----------|----|---------|-----------|---|----|----|
| lb      | lb        | 20 | C.      | C.        | Q | lb | 20 |
| 1       | —         | 9  | 1       | —         | 1 | 22 | 8  |
| 2       | —         | 18 | 2       | —         | 3 | 16 | 16 |
| 3       | 1         | 7  | 3       | 1         | 1 | 11 | 4  |
| 4       | 1         | 16 | 4       | 1         | 3 | 5  | 12 |
| 5       | 2         | 5  | 5       | 2         | 1 | —  | —  |
| 6       | 2         | 14 | 6       | 2         | 2 | 22 | 8  |
| 7       | 3         | 3  | 7       | 3         | — | 16 | 16 |
| 8       | 3         | 12 | 8       | 3         | 2 | 11 | 4  |
| 9       | 4         | 1  | 9       | 4         | — | 5  | 12 |
| 10      | 4         | 10 | 10      | 4         | 2 | —  | —  |
| 11      | 4         | 19 | 20      | 9         | — | —  | —  |
| 12      | 5         | 8  | 30      | 13        | 2 | —  | —  |
| 13      | 5         | 17 | 40      | 18        | — | —  | —  |
| 14      | 6         | 6  | 50      | 22        | 2 | —  | —  |
|         |           |    | 60      | 27        | — | —  | —  |
| 28      | 12        | 12 | 70      | 31        | 2 | —  | —  |
| 56      | 25        | 4  | 80      | 36        | — | —  | —  |
| 84      | 37        | 16 | 90      | 40        | 2 | —  | —  |
|         |           |    | 100     | 45        | — | —  | —  |
|         |           |    | 200     | 90        | — | —  | —  |

At  $9\frac{1}{2}$  for 20

| Bl. Tin | White Tin |                | Bl. Tin | White Tin |   |    |    |
|---------|-----------|----------------|---------|-----------|---|----|----|
| lb      | lb        | 20             | C.      | C.        | Q | lb | 20 |
| 1       | —         | $9\frac{1}{2}$ | 1       | —         | 1 | 25 | 4  |
| 2       | —         | 19             | 2       | —         | 3 | 22 | 8  |
| 3       | 1         | $8\frac{1}{2}$ | 3       | 1         | 1 | 19 | 12 |
| 4       | 1         | 18             | 4       | 1         | 3 | 16 | 16 |
| 5       | 2         | $7\frac{1}{2}$ | 5       | 2         | 1 | 14 | —  |
| 6       | 2         | 17             | 6       | 2         | 3 | 11 | 4  |
| 7       | 3         | $6\frac{1}{2}$ | 7       | 3         | 1 | 8  | 8  |
| 8       | 3         | 16             | 8       | 3         | 3 | 5  | 12 |
| 9       | 4         | $5\frac{1}{2}$ | 9       | 4         | 1 | 2  | 16 |
| 10      | 4         | 15             | 10      | 4         | 3 | —  | —  |
| 11      | 5         | $4\frac{1}{2}$ | 20      | 9         | 2 | —  | —  |
| 12      | 5         | 14             | 30      | 14        | 1 | —  | —  |
| 13      | 6         | $3\frac{1}{2}$ | 40      | 19        | — | —  | —  |
| 14      | 6         | 13             | 50      | 23        | 3 | —  | —  |
|         |           |                | 60      | 28        | 2 | —  | —  |
| 28      | 13        | 6              | 70      | 33        | 1 | —  | —  |
| 56      | 26        | 12             | 80      | 38        | — | —  | —  |
| 84      | 39        | 18             | 90      | 42        | 3 | —  | —  |
|         |           |                | 100     | 47        | 2 | —  | —  |
|         |           |                | 200     | 95        | — | —  | —  |

At  $9\frac{3}{4}$  for 20

| Bl. Tin | White Tin |                 | Bl. Tin | White Tin |   |    |    |
|---------|-----------|-----------------|---------|-----------|---|----|----|
| lb      | lb        | 20              | C.      | C.        | Q | lb | 20 |
| 1       | —         | $9\frac{3}{4}$  | 1       | —         | 1 | 23 | 16 |
| 2       | —         | $18\frac{1}{2}$ | 2       | —         | 3 | 19 | 12 |
| 3       | 1         | $7\frac{3}{4}$  | 3       | 1         | 1 | 15 | 8  |
| 4       | 1         | 17              | 4       | 1         | 3 | 11 | 4  |
| 5       | 2         | $6\frac{1}{4}$  | 5       | 2         | 1 | 7  | —  |
| 6       | 2         | $15\frac{1}{2}$ | 6       | 2         | 3 | 2  | 16 |
| 7       | 3         | $4\frac{3}{4}$  | 7       | 3         | — | 26 | 12 |
| 8       | 3         | 14              | 8       | 3         | 2 | 22 | 8  |
| 9       | 4         | $3\frac{1}{4}$  | 9       | 4         | — | 18 | 4  |
| 10      | 4         | $12\frac{1}{2}$ | 10      | 4         | 2 | 14 | —  |
| 11      | 5         | $1\frac{3}{4}$  | 20      | 9         | 1 | —  | —  |
| 12      | 5         | 11              | 30      | 13        | 3 | 14 | —  |
| 13      | 6         | $\frac{1}{4}$   | 40      | 18        | 2 | —  | —  |
| 14      | 6         | $9\frac{1}{2}$  | 50      | 23        | — | 14 | —  |
|         |           |                 | 60      | 27        | 3 | —  | —  |
| 28      | 12        | 19              | 70      | 32        | 1 | 14 | —  |
| 56      | 25        | 18              | 80      | 37        | — | —  | —  |
| 84      | 38        | 17              | 90      | 41        | 2 | 14 | —  |
|         |           |                 | 100     | 46        | 1 | —  | —  |
|         |           |                 | 200     | 92        | — | —  | —  |

At  $9\frac{1}{4}$  for 20

| Bl. Tin | White Tin |                 | Bl. Tin | White Tin |   |    |    |
|---------|-----------|-----------------|---------|-----------|---|----|----|
| lb      | lb        | 20              | C.      | C.        | Q | lb | 20 |
| 1       | —         | $9\frac{1}{4}$  | 1       | —         | 1 | 26 | 12 |
| 2       | —         | $19\frac{1}{2}$ | 2       | —         | 3 | 25 | 4  |
| 3       | 1         | $9\frac{1}{4}$  | 3       | 1         | 1 | 23 | 16 |
| 4       | 1         | 19              | 4       | 1         | 3 | 22 | 8  |
| 5       | 2         | $8\frac{3}{4}$  | 5       | 2         | 1 | 21 | —  |
| 6       | 2         | $18\frac{1}{2}$ | 6       | 2         | 3 | 19 | 12 |
| 7       | 3         | $8\frac{1}{4}$  | 7       | 3         | 1 | 18 | 4  |
| 8       | 3         | 18              | 8       | 3         | 3 | 16 | 16 |
| 9       | 4         | $7\frac{3}{4}$  | 9       | 4         | 1 | 15 | 8  |
| 10      | 4         | $17\frac{1}{2}$ | 10      | 4         | 3 | 14 | —  |
| 11      | 5         | $7\frac{1}{4}$  | 20      | 9         | 3 | —  | —  |
| 12      | 5         | 17              | 30      | 14        | 2 | 14 | —  |
| 13      | 6         | $6\frac{3}{4}$  | 40      | 19        | 2 | —  | —  |
| 14      | 6         | $16\frac{1}{2}$ | 50      | 24        | 1 | 14 | —  |
|         |           |                 | 60      | 29        | 1 | —  | —  |
| 28      | 13        | 13              | 70      | 34        | — | 14 | —  |
| 56      | 27        | 6               | 80      | 39        | — | —  | —  |
| 84      | 40        | 19              | 90      | 43        | 3 | 14 | —  |
|         |           |                 | 100     | 48        | 3 | —  | —  |
|         |           |                 | 200     | 97        | 2 | —  | —  |

H h h h



At 10 for 20

| Bl.<br>Tin | White Tin |    | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|----|------------|-----------|---|----|----|
| lb         | lb        | 20 | C.         | C.        | Q | lb | 20 |
| 1          | —         | 10 | 1          | —         | 2 | —  | —  |
| 2          | 1         | —  | 2          | 1         | — | —  | —  |
| 3          | 1         | 10 | 3          | 1         | 2 | —  | —  |
| 4          | 2         | —  | 4          | 2         | — | —  | —  |
| 5          | 2         | 10 | 5          | 2         | 2 | —  | —  |
| 6          | 3         | —  | 6          | 3         | — | —  | —  |
| 7          | 3         | 10 | 7          | 3         | 2 | —  | —  |
| 8          | 4         | —  | 8          | 4         | — | —  | —  |
| 9          | 4         | 10 | 9          | 4         | 2 | —  | —  |
| 10         | 5         | —  | 10         | 5         | — | —  | —  |
| 11         | 5         | 10 | 20         | 10        | — | —  | —  |
| 12         | 6         | —  | 30         | 15        | — | —  | —  |
| 13         | 6         | 10 | 40         | 20        | — | —  | —  |
| 14         | 7         | —  | 50         | 25        | — | —  | —  |
|            |           |    | 60         | 30        | — | —  | —  |
| 28         | 14        | —  | 70         | 35        | — | —  | —  |
| 56         | 28        | —  | 80         | 40        | — | —  | —  |
| 84         | 42        | —  | 90         | 45        | — | —  | —  |
|            |           |    | 100        | 50        | — | —  | —  |
|            |           |    | 200        | 100       | — | —  | —  |

At  $10\frac{1}{2}$  for 20

| Bl.<br>Tin | White Tin |                 | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|-----------------|------------|-----------|---|----|----|
| lb         | lb        | 20              | C.         | C.        | Q | lb | 20 |
| 1          | —         | $10\frac{1}{2}$ | 1          | —         | 2 | 2  | 16 |
| 2          | 1         | 1               | 2          | 1         | — | 5  | 12 |
| 3          | 1         | $11\frac{1}{2}$ | 3          | 1         | 2 | 8  | 8  |
| 4          | 2         | 2               | 4          | 2         | — | 11 | 4  |
| 5          | 2         | $12\frac{1}{2}$ | 5          | 2         | 2 | 14 | —  |
| 6          | 3         | 3               | 6          | 3         | — | 16 | 16 |
| 7          | 3         | $13\frac{1}{2}$ | 7          | 3         | 2 | 19 | 12 |
| 8          | 4         | 4               | 8          | 4         | — | 22 | 8  |
| 9          | 4         | $14\frac{1}{2}$ | 9          | 4         | 2 | 25 | 4  |
| 10         | 5         | 5               | 10         | 5         | 1 | —  | —  |
| 11         | 5         | $15\frac{1}{2}$ | 20         | 10        | 2 | —  | —  |
| 12         | 6         | 6               | 30         | 15        | 3 | —  | —  |
| 13         | 6         | $16\frac{1}{2}$ | 40         | 21        | — | —  | —  |
| 14         | 7         | 7               | 50         | 26        | 1 | —  | —  |
|            |           |                 | 60         | 31        | 2 | —  | —  |
| 28         | 14        | 14              | 70         | 36        | 3 | —  | —  |
| 56         | 29        | 8               | 80         | 42        | — | —  | —  |
| 84         | 44        | 2               | 90         | 47        | 1 | —  | —  |
|            |           |                 | 100        | 52        | 2 | —  | —  |
|            |           |                 | 200        | 105       | — | —  | —  |

At  $10\frac{1}{4}$  for 20

| Bl.<br>Tin | White Tin |                 | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|-----------------|------------|-----------|---|----|----|
| lb         | lb        | 20              | C.         | C.        | Q | lb | 20 |
| 1          | —         | $10\frac{1}{4}$ | 1          | —         | 2 | 1  | 8  |
| 2          | 1         | $10\frac{1}{2}$ | 2          | 1         | — | 2  | 16 |
| 3          | 1         | $10\frac{3}{4}$ | 3          | 1         | 2 | 4  | 4  |
| 4          | 2         | 1               | 4          | 2         | — | 5  | 12 |
| 5          | 2         | $11\frac{1}{4}$ | 5          | 2         | 2 | 7  | —  |
| 6          | 3         | $11\frac{1}{2}$ | 6          | 3         | — | 8  | 8  |
| 7          | 3         | $11\frac{3}{4}$ | 7          | 3         | 2 | 9  | 16 |
| 8          | 4         | 2               | 8          | 4         | — | 11 | 4  |
| 9          | 4         | $12\frac{1}{4}$ | 9          | 4         | 2 | 12 | 12 |
| 10         | 5         | $12\frac{1}{2}$ | 10         | 5         | — | 14 | —  |
| 11         | 5         | $12\frac{3}{4}$ | 20         | 10        | 1 | —  | —  |
| 12         | 6         | 3               | 30         | 15        | 1 | 14 | —  |
| 13         | 6         | $13\frac{1}{4}$ | 40         | 20        | 2 | —  | —  |
| 14         | 7         | $13\frac{1}{2}$ | 50         | 25        | 2 | 14 | —  |
|            |           |                 | 60         | 30        | 3 | —  | —  |
| 28         | 14        | 7               | 70         | 35        | 3 | 14 | —  |
| 56         | 28        | 14              | 80         | 41        | — | —  | —  |
| 84         | 43        | 1               | 90         | 46        | — | 14 | —  |
|            |           |                 | 100        | 51        | 1 | —  | —  |
|            |           |                 | 200        | 102       | 2 | —  | —  |

At  $10\frac{3}{4}$  for 20

| Bl.<br>Tin | White Tin |                 | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|-----------------|------------|-----------|---|----|----|
| lb         | lb        | 20              | C.         | C.        | Q | lb | 20 |
| 1          | —         | $10\frac{3}{4}$ | 1          | —         | 2 | 4  | 4  |
| 2          | 1         | $11\frac{1}{2}$ | 2          | 1         | — | 8  | 8  |
| 3          | 1         | $12\frac{1}{4}$ | 3          | 1         | 2 | 12 | 12 |
| 4          | 2         | 3               | 4          | 2         | — | 16 | 16 |
| 5          | 2         | $13\frac{3}{4}$ | 5          | 2         | 2 | 21 | —  |
| 6          | 3         | $14\frac{1}{2}$ | 6          | 3         | — | 25 | 4  |
| 7          | 3         | $15\frac{1}{4}$ | 7          | 3         | 3 | 1  | 8  |
| 8          | 4         | 6               | 8          | 4         | 1 | 5  | 12 |
| 9          | 4         | $16\frac{3}{4}$ | 9          | 4         | 3 | 9  | 16 |
| 10         | 5         | $17\frac{1}{2}$ | 10         | 5         | 1 | 14 | —  |
| 11         | 5         | $18\frac{1}{4}$ | 20         | 10        | 3 | —  | —  |
| 12         | 6         | 9               | 30         | 16        | — | 14 | —  |
| 13         | 6         | $19\frac{3}{4}$ | 40         | 21        | 2 | —  | —  |
| 14         | 7         | $20\frac{1}{2}$ | 50         | 26        | 3 | 14 | —  |
|            |           |                 | 60         | 32        | 1 | —  | —  |
| 28         | 15        | 1               | 70         | 37        | 2 | 14 | —  |
| 56         | 30        | 2               | 80         | 43        | — | —  | —  |
| 84         | 45        | 3               | 90         | 48        | 1 | 14 | —  |
|            |           |                 | 100        | 53        | 3 | —  | —  |
|            |           |                 | 200        | 107       | 2 | —  | —  |



At 11 for 20

| Bl.<br>Tin | White Tin |    | Bl.<br>Tin | White Tin |         |
|------------|-----------|----|------------|-----------|---------|
| lb         | lb        | 20 | C.         | C.        | Q lb 20 |
| 1          | —         | 11 | 1          | —         | 2 5 12  |
| 2          | 1         | 2  | 2          | 1         | 11 4    |
| 3          | 1         | 13 | 3          | 1         | 2 16 16 |
| 4          | 2         | 4  | 4          | 2         | — 22 8  |
| 5          | 2         | 15 | 5          | 2         | 3 —     |
| 6          | 3         | 6  | 6          | 3         | 1 5 12  |
| 7          | 3         | 17 | 7          | 3         | 3 11 4  |
| 8          | 4         | 8  | 8          | 4         | 1 16 16 |
| 9          | 4         | 19 | 9          | 4         | 3 22 8  |
| 10         | 5         | 10 | 10         | 5         | 2 —     |
| 11         | 6         | 1  | 20         | 11        | — —     |
| 12         | 6         | 12 | 30         | 16        | 2 —     |
| 13         | 7         | 3  | 40         | 22        | — —     |
| 14         | 7         | 14 | 50         | 27        | 2 —     |
|            |           |    | 60         | 33        | — —     |
| 28         | 15        | 8  | 70         | 38        | 2 —     |
| 56         | 30        | 16 | 80         | 44        | — —     |
| 84         | 46        | 4  | 90         | 49        | 2 —     |
|            |           |    | 100        | 55        | — —     |
|            |           |    | 200        | 110       | — —     |

At 11½ for 20

| Bl.<br>Tin | White Tin |     | Bl.<br>Tin | White Tin |         |
|------------|-----------|-----|------------|-----------|---------|
| lb         | lb        | 20  | C.         | C.        | Q lb 20 |
| 1          | —         | 11½ | 1          | —         | 2 8 8   |
| 2          | 1         | 3   | 2          | 1         | — 16 16 |
| 3          | 1         | 14½ | 3          | 1         | 2 25 4  |
| 4          | 2         | 6   | 4          | 2         | 1 5 12  |
| 5          | 2         | 17½ | 5          | 2         | 3 14 —  |
| 6          | 3         | 9   | 6          | 3         | 1 22 8  |
| 7          | 4         | ½   | 7          | 4         | — 2 16  |
| 8          | 4         | 12  | 8          | 4         | 2 11 4  |
| 9          | 5         | 3½  | 9          | 5         | — 19 12 |
| 10         | 5         | 15  | 10         | 5         | 3 —     |
| 11         | 6         | 6½  | 20         | 11        | 2 —     |
| 12         | 6         | 18  | 30         | 17        | 1 —     |
| 13         | 7         | 9½  | 40         | 23        | — —     |
| 14         | 8         | 1   | 50         | 28        | 3 —     |
|            |           |     | 60         | 34        | 2 —     |
| 28         | 16        | 2   | 70         | 40        | 1 —     |
| 56         | 32        | 4   | 80         | 46        | — —     |
| 84         | 48        | 6   | 90         | 51        | 3 —     |
|            |           |     | 100        | 57        | 2 —     |
|            |           |     | 200        | 115       | — —     |

At 11¼ for 20

| Bl.<br>Tin | White Tin |     | Bl.<br>Tin | White Tin |         |
|------------|-----------|-----|------------|-----------|---------|
| lb         | lb        | 20  | C.         | C.        | Q lb 20 |
| 1          | —         | 11¼ | 1          | —         | 2 7 —   |
| 2          | 1         | 2½  | 2          | 1         | — 14 —  |
| 3          | 1         | 13¼ | 3          | 1         | 2 21 —  |
| 4          | 2         | 5   | 4          | 2         | 1 — —   |
| 5          | 2         | 16¼ | 5          | 2         | 3 7 —   |
| 6          | 3         | 7½  | 6          | 3         | 1 14 —  |
| 7          | 3         | 18¼ | 7          | 3         | 3 21 —  |
| 8          | 4         | 10  | 8          | 4         | 2 — —   |
| 9          | 5         | 1¼  | 9          | 5         | — 7 —   |
| 10         | 5         | 12½ | 10         | 5         | 2 14 —  |
| 11         | 6         | 3¾  | 20         | 11        | 1 — —   |
| 12         | 6         | 15  | 30         | 16        | 3 14 —  |
| 13         | 7         | 6¼  | 40         | 22        | 2 — —   |
| 14         | 7         | 17½ | 50         | 28        | — 14 —  |
|            |           |     | 60         | 33        | 3 — —   |
| 28         | 15        | 15  | 70         | 39        | 1 14 —  |
| 56         | 31        | 10  | 80         | 45        | — — —   |
| 84         | 47        | 5   | 90         | 50        | 2 14 —  |
|            |           |     | 100        | 56        | 1 — —   |
|            |           |     | 200        | 112       | 2 — —   |

At 11½ for 20

| Bl.<br>Tin | White Tin |     | Bl.<br>Tin | White Tin |         |
|------------|-----------|-----|------------|-----------|---------|
| lb         | lb        | 20  | C.         | C.        | Q lb 20 |
| 1          | —         | 11½ | 1          | —         | 2 9 16  |
| 2          | 1         | 3½  | 2          | 1         | — 19 12 |
| 3          | 1         | 15¼ | 3          | 1         | 3 1 8   |
| 4          | 2         | 7   | 4          | 2         | 1 11 4  |
| 5          | 2         | 18¼ | 5          | 2         | 3 21 —  |
| 6          | 3         | 10½ | 6          | 3         | 2 2 16  |
| 7          | 4         | 2¼  | 7          | 4         | — 12 12 |
| 8          | 4         | 14  | 8          | 4         | 2 22 8  |
| 9          | 5         | 5¾  | 9          | 5         | 1 4 4   |
| 10         | 5         | 17½ | 10         | 5         | 3 14 —  |
| 11         | 6         | 9¼  | 20         | 11        | 3 — —   |
| 12         | 7         | 1   | 30         | 17        | 2 14 —  |
| 13         | 7         | 12¾ | 40         | 23        | 2 — —   |
| 14         | 8         | 4½  | 50         | 29        | 1 14 —  |
|            |           |     | 60         | 35        | 1 — —   |
| 28         | 16        | 9   | 70         | 41        | — 14 —  |
| 56         | 32        | 18  | 80         | 47        | — — —   |
| 84         | 49        | 7   | 90         | 52        | 3 14 —  |
|            |           |     | 100        | 58        | 3 — —   |
|            |           |     | 200        | 117       | 2 — —   |



At 12 for 20

| Bl. Tin | White Tin |    | Bl. Tin | White Tin |   |    |    |
|---------|-----------|----|---------|-----------|---|----|----|
| lb      | lb        | 20 | C.      | C.        | Q | lb | 20 |
| 1       | —         | 12 | 1       | —         | 2 | 11 | 4  |
| 2       | 1         | 4  | 2       | 1         | — | 22 | 8  |
| 3       | 1         | 16 | 3       | 1         | 3 | 5  | 12 |
| 4       | 2         | 8  | 4       | 2         | 1 | 16 | 16 |
| 5       | 3         | —  | 5       | 3         | — | —  | —  |
| 6       | 3         | 12 | 6       | 3         | 2 | 11 | 4  |
| 7       | 4         | 4  | 7       | 4         | — | 22 | 8  |
| 8       | 4         | 16 | 8       | 4         | 3 | 5  | 12 |
| 9       | 5         | 8  | 9       | 5         | 1 | 16 | 16 |
| 10      | 6         | —  | 10      | 6         | — | —  | —  |
| 11      | 6         | 12 | 20      | 12        | — | —  | —  |
| 12      | 7         | 4  | 30      | 18        | — | —  | —  |
| 13      | 7         | 16 | 40      | 24        | — | —  | —  |
| 14      | 8         | 8  | 50      | 30        | — | —  | —  |
|         |           |    | 60      | 36        | — | —  | —  |
| 28      | 16        | 16 | 70      | 42        | — | —  | —  |
| 56      | 33        | 12 | 80      | 48        | — | —  | —  |
| 84      | 50        | 8  | 90      | 54        | — | —  | —  |
|         |           |    | 100     | 60        | — | —  | —  |
|         |           |    | 200     | 120       | — | —  | —  |

At  $12\frac{1}{2}$  for 20

| Bl. Tin | White Tin |                 | Bl. Tin | White Tin |   |    |    |
|---------|-----------|-----------------|---------|-----------|---|----|----|
| lb      | lb        | 20              | C.      | C.        | Q | lb | 20 |
| 1       | —         | $12\frac{1}{2}$ | 1       | —         | 2 | 14 | —  |
| 2       | 1         | 5               | 2       | 1         | 1 | —  | —  |
| 3       | 1         | $17\frac{1}{2}$ | 3       | 1         | 3 | 14 | —  |
| 4       | 2         | 10              | 4       | 2         | 2 | —  | —  |
| 5       | 3         | $2\frac{1}{2}$  | 5       | 3         | — | 14 | —  |
| 6       | 3         | 15              | 6       | 3         | 3 | —  | —  |
| 7       | 4         | $7\frac{1}{2}$  | 7       | 4         | 1 | 14 | —  |
| 8       | 5         | —               | 8       | 5         | — | —  | —  |
| 9       | 5         | $12\frac{1}{2}$ | 9       | 5         | 2 | 14 | —  |
| 10      | 6         | 5               | 10      | 6         | 1 | —  | —  |
| 11      | 6         | $17\frac{1}{2}$ | 20      | 12        | 2 | —  | —  |
| 12      | 7         | 10              | 30      | 18        | 3 | —  | —  |
| 13      | 8         | $2\frac{1}{2}$  | 40      | 25        | — | —  | —  |
| 14      | 8         | 15              | 50      | 31        | 1 | —  | —  |
|         |           |                 | 60      | 37        | 2 | —  | —  |
| 28      | 17        | 10              | 70      | 43        | 3 | —  | —  |
| 56      | 35        | —               | 80      | 50        | — | —  | —  |
| 84      | 52        | 10              | 90      | 56        | 1 | —  | —  |
|         |           |                 | 100     | 62        | 2 | —  | —  |
|         |           |                 | 200     | 125       | — | —  | —  |

At  $12\frac{3}{4}$  for 20

| Bl. Tin | White Tin |                 | Bl. Tin | White Tin |   |    |    |
|---------|-----------|-----------------|---------|-----------|---|----|----|
| lb      | lb        | 20              | C.      | C.        | Q | lb | 20 |
| 1       | —         | $12\frac{3}{4}$ | 1       | —         | 2 | 12 | 12 |
| 2       | 1         | $4\frac{1}{2}$  | 2       | 1         | — | 25 | 4  |
| 3       | 1         | $16\frac{3}{4}$ | 3       | 1         | 3 | 9  | 16 |
| 4       | 2         | 9               | 4       | 2         | 1 | 22 | 8  |
| 5       | 3         | $1\frac{1}{4}$  | 5       | 3         | — | 7  | —  |
| 6       | 3         | $13\frac{1}{2}$ | 6       | 3         | 2 | 19 | 12 |
| 7       | 4         | $5\frac{3}{4}$  | 7       | 4         | 1 | 4  | 4  |
| 8       | 4         | 18              | 8       | 4         | 3 | 16 | 16 |
| 9       | 5         | $10\frac{1}{4}$ | 9       | 5         | 2 | 1  | 8  |
| 10      | 6         | $2\frac{1}{2}$  | 10      | 6         | — | 14 | —  |
| 11      | 6         | $14\frac{3}{4}$ | 20      | 12        | 1 | —  | —  |
| 12      | 7         | 7               | 30      | 18        | 1 | 14 | —  |
| 13      | 7         | $19\frac{1}{4}$ | 40      | 24        | 2 | —  | —  |
| 14      | 8         | $11\frac{1}{2}$ | 50      | 30        | 2 | 14 | —  |
|         |           |                 | 60      | 36        | 3 | —  | —  |
| 28      | 17        | 3               | 70      | 42        | 3 | 14 | —  |
| 56      | 34        | 6               | 80      | 49        | — | —  | —  |
| 84      | 51        | 9               | 90      | 55        | — | 14 | —  |
|         |           |                 | 100     | 61        | 1 | —  | —  |
|         |           |                 | 200     | 122       | 2 | —  | —  |

At  $12\frac{3}{4}$  for 20

| Bl. Tin | White Tin |                 | Bl. Tin | White Tin |   |    |    |
|---------|-----------|-----------------|---------|-----------|---|----|----|
| lb      | lb        | 20              | C.      | C.        | Q | lb | 20 |
| 1       | —         | $12\frac{3}{4}$ | 1       | —         | 2 | 15 | 8  |
| 2       | 1         | $5\frac{1}{2}$  | 2       | 1         | 1 | 2  | 16 |
| 3       | 1         | $18\frac{1}{4}$ | 3       | 1         | 3 | 18 | 4  |
| 4       | 2         | 11              | 4       | 2         | 2 | 5  | 12 |
| 5       | 3         | $3\frac{3}{4}$  | 5       | 3         | — | 21 | —  |
| 6       | 3         | $16\frac{1}{2}$ | 6       | 3         | 3 | 8  | 8  |
| 7       | 4         | $9\frac{1}{4}$  | 7       | 4         | 1 | 23 | 16 |
| 8       | 5         | 2               | 8       | 5         | — | 11 | 4  |
| 9       | 5         | $14\frac{3}{4}$ | 9       | 5         | 2 | 26 | 12 |
| 10      | 6         | $7\frac{1}{2}$  | 10      | 6         | 1 | 14 | —  |
| 11      | 7         | $\frac{1}{4}$   | 20      | 12        | 3 | —  | —  |
| 12      | 7         | 13              | 30      | 19        | — | 14 | —  |
| 13      | 8         | $5\frac{3}{4}$  | 40      | 25        | 2 | —  | —  |
| 14      | 8         | $18\frac{1}{2}$ | 50      | 31        | 3 | 14 | —  |
|         |           |                 | 60      | 38        | 1 | —  | —  |
| 28      | 17        | 17              | 70      | 44        | 2 | 14 | —  |
| 56      | 35        | 14              | 80      | 51        | — | —  | —  |
| 84      | 53        | 11              | 90      | 57        | 1 | 14 | —  |
|         |           |                 | 100     | 63        | 3 | —  | —  |
|         |           |                 | 200     | 127       | 2 | —  | —  |



At 13 for 20

| Bl.<br>Tin | White Tin |    | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|----|------------|-----------|---|----|----|
| lb         | lb        | 20 | C.         | C.        | Q | lb | 20 |
| 1          | —         | 13 | 1          | —         | 2 | 16 | 16 |
| 2          | 1         | 6  | 2          | 1         | 1 | 5  | 12 |
| 3          | 1         | 19 | 3          | 1         | 3 | 22 | 8  |
| 4          | 2         | 12 | 4          | 2         | 2 | 11 | 4  |
| 5          | 3         | 5  | 5          | 3         | 1 | —  | —  |
| 6          | 3         | 18 | 6          | 3         | 3 | 16 | 8  |
| 7          | 4         | 11 | 7          | 4         | 2 | 5  | 12 |
| 8          | 5         | 4  | 8          | 5         | — | 22 | 8  |
| 9          | 5         | 17 | 9          | 5         | 3 | 11 | 4  |
| 10         | 6         | 10 | 10         | 6         | 2 | —  | —  |
| 11         | 7         | 3  | 20         | 13        | — | —  | —  |
| 12         | 7         | 16 | 30         | 19        | 2 | —  | —  |
| 13         | 8         | 9  | 40         | 26        | — | —  | —  |
| 14         | 9         | 2  | 50         | 32        | 2 | —  | —  |
|            |           |    | 60         | 39        | — | —  | —  |
| 28         | 18        | 4  | 70         | 45        | 2 | —  | —  |
| 56         | 36        | 8  | 80         | 52        | — | —  | —  |
| 84         | 54        | 12 | 90         | 58        | 2 | —  | —  |
|            |           |    | 100        | 65        | — | —  | —  |
|            |           |    | 200        | 130       | — | —  | —  |

At  $13\frac{1}{2}$  for 20

| Bl.<br>Tin | White Tin |                 | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|-----------------|------------|-----------|---|----|----|
| lb         | lb        | 20              | C.         | C.        | Q | lb | 20 |
| 1          | —         | $13\frac{1}{2}$ | 1          | —         | 2 | 19 | 12 |
| 2          | 1         | 7               | 2          | 1         | 1 | 11 | 4  |
| 3          | 2         | $\frac{1}{2}$   | 3          | 2         | — | 2  | 16 |
| 4          | 2         | 14              | 4          | 2         | 2 | 22 | 8  |
| 5          | 3         | $7\frac{1}{2}$  | 5          | 3         | 1 | 14 | —  |
| 6          | 4         | 1               | 6          | 4         | — | 5  | 12 |
| 7          | 4         | $14\frac{1}{2}$ | 7          | 4         | 2 | 25 | 4  |
| 8          | 5         | 8               | 8          | 5         | 1 | 16 | 16 |
| 9          | 6         | $1\frac{1}{2}$  | 9          | 6         | — | 8  | 8  |
| 10         | 6         | 15              | 10         | 6         | 3 | —  | —  |
| 11         | 7         | $8\frac{1}{2}$  | 20         | 13        | 2 | —  | —  |
| 12         | 8         | 2               | 30         | 20        | 1 | —  | —  |
| 13         | 8         | $15\frac{1}{2}$ | 40         | 27        | — | —  | —  |
| 14         | 9         | 9               | 50         | 33        | 3 | —  | —  |
|            |           |                 | 60         | 40        | 2 | —  | —  |
| 28         | 18        | 18              | 70         | 47        | 1 | —  | —  |
| 56         | 37        | 16              | 80         | 54        | — | —  | —  |
| 84         | 56        | 14              | 90         | 60        | 3 | —  | —  |
|            |           |                 | 100        | 67        | 2 | —  | —  |
|            |           |                 | 200        | 135       | — | —  | —  |

At  $13\frac{1}{4}$  for 20

| Bl.<br>Tin | White Tin |                 | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|-----------------|------------|-----------|---|----|----|
| lb         | lb        | 20              | C.         | C.        | Q | lb | 20 |
| 1          | —         | $13\frac{1}{4}$ | 1          | —         | 2 | 18 | 4  |
| 2          | 1         | $6\frac{1}{2}$  | 2          | 1         | 1 | 8  | 8  |
| 3          | 1         | $19\frac{3}{4}$ | 3          | 1         | 3 | 26 | 12 |
| 4          | 2         | 13              | 4          | 2         | 2 | 16 | 16 |
| 5          | 3         | $6\frac{1}{4}$  | 5          | 3         | 1 | 7  | —  |
| 6          | 3         | $19\frac{1}{2}$ | 6          | 3         | 3 | 25 | 4  |
| 7          | 4         | $12\frac{3}{4}$ | 7          | 4         | 2 | 15 | 8  |
| 8          | 5         | 6               | 8          | 5         | 1 | 5  | 12 |
| 9          | 5         | $19\frac{1}{4}$ | 9          | 5         | 3 | 23 | 16 |
| 10         | 6         | $12\frac{1}{2}$ | 10         | 6         | 2 | 14 | —  |
| 11         | 7         | $5\frac{3}{4}$  | 20         | 13        | 1 | —  | —  |
| 12         | 7         | 19              | 30         | 19        | 3 | 14 | —  |
| 13         | 8         | $12\frac{1}{4}$ | 40         | 26        | 2 | —  | —  |
| 14         | 9         | $5\frac{1}{2}$  | 50         | 33        | — | 14 | —  |
|            |           |                 | 60         | 39        | 3 | —  | —  |
| 28         | 18        | 11              | 70         | 46        | 1 | 14 | —  |
| 56         | 37        | 2               | 80         | 53        | — | —  | —  |
| 84         | 55        | 13              | 90         | 59        | 2 | 14 | —  |
|            |           |                 | 100        | 66        | 1 | —  | —  |
|            |           |                 | 200        | 132       | 2 | —  | —  |

At  $13\frac{3}{4}$  for 20

| Bl.<br>Tin | White Tin |                 | Bl.<br>Tin | White Tin |   |    |    |
|------------|-----------|-----------------|------------|-----------|---|----|----|
| lb         | lb        | 20              | C.         | C.        | Q | lb | 20 |
| 1          | —         | $13\frac{3}{4}$ | 1          | —         | 2 | 21 | —  |
| 2          | 1         | $7\frac{1}{2}$  | 2          | 1         | 1 | 14 | —  |
| 3          | 2         | $1\frac{1}{4}$  | 3          | 2         | — | 7  | —  |
| 4          | 2         | 15              | 4          | 2         | 3 | —  | —  |
| 5          | 3         | $8\frac{3}{4}$  | 5          | 3         | 1 | 21 | —  |
| 6          | 4         | $2\frac{1}{2}$  | 6          | 4         | — | 14 | —  |
| 7          | 4         | $16\frac{1}{4}$ | 7          | 4         | 3 | 7  | —  |
| 8          | 5         | 10              | 8          | 5         | 2 | —  | —  |
| 9          | 6         | $3\frac{3}{4}$  | 9          | 6         | — | 21 | —  |
| 10         | 6         | $17\frac{1}{2}$ | 10         | 6         | 3 | 14 | —  |
| 11         | 7         | $11\frac{1}{4}$ | 20         | 13        | 3 | —  | —  |
| 12         | 8         | 5               | 30         | 20        | 2 | 14 | —  |
| 13         | 8         | $18\frac{3}{4}$ | 40         | 27        | 2 | —  | —  |
| 14         | 9         | $12\frac{1}{2}$ | 50         | 34        | 1 | 14 | —  |
|            |           |                 | 60         | 41        | 1 | —  | —  |
| 28         | 19        | 5               | 70         | 48        | — | 14 | —  |
| 56         | 38        | 10              | 80         | 55        | — | —  | —  |
| 84         | 57        | 15              | 90         | 61        | 3 | 14 | —  |
|            |           |                 | 100        | 68        | 3 | —  | —  |
|            |           |                 | 200        | 137       | 2 | —  | —  |







## A P P E N D I X.

**A**MONG the variety of improvements that may be suggested for the interest of Mining, those certainly are most beneficial, which tend to the perfection of mechanicks and hydraulicks; for had there not been great progress made in those branches of philosophy within the last improved ages of science, Mining would still consist of merely digging a few fathoms deep, and raising the stuff and water, by dint of human labour.

About four-score years back, small wheels of twelve or fifteen feet diameter, were thought the best machinery for draining the Mines; and if one or two were insufficient, more were often applied to that purpose, all worked by the same stream of water. I have heard of seven in one Mine, worked over each other. This power must have been attended with a complication of accidents and delays. However, soon after the above date, Mr. John Costar, of Bristol, came into this county, and taught the natives an improvement in this machinery, by demolishing those petit engines, and substituting one large wheel of between thirty and forty feet diameter in their stead.

Hitherto we are all assured, that a large water wheel engine, if water is plenty and cheap, is most effectual and steady for the purpose of draining our Mines; but this power is limited; and beyond a certain gauge we dare not undertake. We know, that if we add to our power, we experience a loss in time or motion, more than equivalent to the acquisition. Upon this principle we understand, that a thirty-eight feet wheel, or thereabout, is the best medium we can prescribe to ourselves; pursuant to which we know, that, beyond a certain depth, we cannot sink with ease and conveniency to our interest; and that another power becomes necessary for our purpose.

It should seem as if we had been led by the kind hand of Providence in those discoveries; for as soon as we found out the ne plus ultra of the power of water, and the necessity of  
further



further improvements in hydraulicks, a new and more scientifick machinery presented itself to the attention of the Miner. For want of another piece of machinery, we had been stinted to a certain depth, beyond which the succeeding generation by the water wheel and bobs would be unable to sink. So that, happily for us and our posterity, Mr. Newcomen's invention of the steam fire engine, even in the weakness of its infancy, promised that future excellence to which it is since arrived, whereby we are enabled to sink our Mines to twice the depth we could formerly do by any other machinery.

Since the improvement of this machine's working itself, by opening and closing the regulator and injection cock, most other attempts have been very unsuccessful. The vast consumption of fuel in those engines, is an immense drawback upon the profits of our Mines. It is a known fact, that every fire engine of magnitude consumes to the amount of three thousand pounds worth of coal in every year. This heavy tax upon Mining, in some respects, amounts to a prohibition. No wonder then, that we should be more desirous to lessen the expence of maintenance in those devouring automats, than frugal in their erection. Many trials of mechanical skill have been made by our engineers, to very little purpose, for the total application of heat and the saving of fuel. The fire place has been diminished, and enlarged again; the flame has been carried round from the bottom of the boiler in a spiral direction, and conveyed through the body of the water in a tube (one, two, or three) before its arrival to the chimney; some have used a double boiler, so that fire might act in every possible point of contact; and some have built a Moorstone boiler, heated by three tubes of flame passing through it.

Indeed, the only improvement which has been made in the fire engine for thirty years past, the publick will very justly attribute to the sagacity of Mr. Watt, whose skill in pneumatics, mechanicks, and hydraulicks, is evidenced by the powerful application of elastick vapour, and by making a more perfect vacuum, nearly like that of the barometer, in his new constructed fire engine.

But before I can explain Mr. Watt's engines, it is necessary to premise a short account of the imperfections of the common steam engines, and their causes.

The



The steam, or vapour, which arises from water confined in a close vessel, and heated a few degrees above the point at which it boils in the open air, becomes an elastick fluid uniform and transparent, about half the gravity of atmospherick air, very much greater in bulk than the water of which it is composed, and capable of being again reduced to water, when brought into contact with matter of a less degree of heat than itself.

The pressure of the atmosphere, or any equivalent resistance, prevents the production of steam, until the water be heated to 212 degrees of Fahrenheit's thermometer; but when that pressure is removed, or the water placed in a vessel exhausted of air, steam is produced from it, when it is colder than the human blood. On the contrary, if water be pressed upon by air or steam, which are more compressed than the atmosphere, a degree of heat above 212 degrees is necessary for the production of steam; and the difference of heats, at which water boils under different pressures, increases in a less proportion than the pressures themselves: so that a double pressure requires less than a double increase of sensible heat.

The experiments which have been published concerning the bulk of water, when converted into steam, are erroneous, and the conclusions drawn from them make that bulk greater than it really is. It has been known for some time, that water would boil in an exhausted receiver, at a low degree of heat; but Mr. Watt was the first that made a regular set of experiments upon the subject, and determined the progression in which the heats followed under various pressures; and, at the same time, made experiments that were decisive upon the true bulk of steam, when compared to the water it is composed of. The result of these experiments he intends to lay before the publick, in a treatise upon that subject.

If we consider the common steam engine, we shall find it defective; first, because the vacuum is produced by throwing cold water into the cylinder to condense the steam; that water becomes hot, and being in a vessel partially exhausted produces a steam, which in part resists the pressure of the atmosphere upon the piston, and lessens the power of the engine. The second defect is the destruction of steam, which unavoidably happens upon attempting to fill a cold cylinder with that fluid: for the injection water, at the same time that it condenses the

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steam,



steam, not only cools the cylinder but remains there, until it be extruded at the eduction pipe, by the steam which is let in to fill the cylinder for the next stroke; and that steam will be condensed into water as fast as it enters, until all the matter it comes into contact with be nearly as hot as itself.

Every attempt to make the vacuum more perfect by the addition of injection water, will cool the cylinder more effectually, and cause a greater destruction of steam in the next filling; and if the engine hath already a proper load, the destruction of steam will proceed in a greater ratio, than the increase of power by the amendment of the vacuum.

Though it appears, that the constructors of steam engines have never investigated these causes; yet they have been so sensible of the effects, that a judicious engineer does not attempt to load his engine with a column of water, heavier than seven pounds for each square inch of the area of the piston.

Mr. Watt's improvement is founded upon these, and some other collateral observations. He preserves an uniform heat in the cylinder of his engines, by suffering no cold water to touch it, and by protecting it from the air, or other cold bodies, by a surrounding case filled with the steam, or with hot air or water, and by coating it over with substances that transmit heat slowly. He makes his vacuum to approach nearly to that of the barometer, by condensing the steam in a separate vessel, called the Condenser, which may be cooled at pleasure without cooling the cylinder, either by an injection of cold water, or by surrounding the condenser with it, and generally by both. He extracts the injection water and detached air, from the cylinder or condenser, by pumps which are wrought by the engine itself, or he blows it out by the steam. As the entrance of air into the cylinder would stop the operation of the engines, and as it is hardly to be expected that such enormous pistons, as those of steam engines, can move up and down, and yet be absolutely air tight in the common engines; a stream of water is kept always running upon the piston, which prevents the entry of the air; but this mode of securing the piston, though not hurtful in the common ones, would be highly prejudicial in the new engines. Their piston is, therefore, made more accurately; and the outer cylinder having a lid which covers it, the steam is introduced above the piston; and when a vacuum is produced under it, acts upon it by its elasticity, as the atmosphere



sphere does upon common engines by its gravity. This way of working, effectually excludes the air from the inner cylinder, and gives the advantage of adding to the power, by increasing the elasticity of the steam.

The internal structure of the new engines so much resembles the common ones, that to those who know that machine, a drawing is scarcely necessary, and I expect they will understand it from the following description.

The cylinder, the great beams, the pumps, &c. stand in their usual positions. The cylinder is smaller than usual in proportion to the load, and is very accurately bored. In the most complete engines, it is surrounded at a small distance with another cylinder, furnished with a bottom and a lid. The interstice between the cylinders, communicates with the boiler by a large pipe, open at both ends; so that it is always filled with steam, and thereby maintains the inner cylinder always of the same heat with the steam, and prevents any condensation within it, which would be more detrimental than an equal condensation in the outer one.

The inner cylinder has a bottom and piston, as usual; and as it does not reach up quite to the lid of the outer cylinder, the steam in the interstice has always free access to the upper side of the piston. The lid of the outer cylinder, has a hole in its middle; and the piston rod, which is made truly cylindrical, moves up and down through that hole, which is kept steam tight by a collar of oakum screwed down upon it.

At the bottom of the inner cylinder, there are two regulating valves, one of which admits the steam to pass from the interstice into the inner cylinder below the piston, or shuts it out at pleasure; the other opens or shuts the end of a pipe, which leads to the condenser. The condenser consists of one or more pumps furnished with clacks and buckets, (nearly the same as in common pumps) which are wrought by chains fastened to the great working beam of the engine. The pipe, which comes from the cylinder, is joined to the bottom of these pumps, and the whole condenser stands immersed in a cistern of cold water supplied by the engine. The place of this cistern is either within the house under the floor, between the cylinder and the lever wall; or without the house, between that wall and the engine shaft; as conveniency may require.

The



The condenser being exhausted of air by blowing, and both the cylinders being filled with steam, the regulating valve which admits the steam into the inner cylinder is shut, and the other regulator which communicates with the condenser is opened, and the steam rushes into the vacuum of the condenser with violence; but there it comes into contact with the cold sides of the pipe and pumps, and meets a jet of cold water which was opened at the same time with the exhaustion regulator; these instantly deprive it of its heat, and reduce it to water; and the vacuum remaining perfect, more steam continues to rush in, and be condensed until the inner cylinder is exhausted. Then the steam which is above the piston, ceasing to be counteracted by that which was below it, acts upon the piston with its whole elasticity, and forces it to descend to the bottom of the cylinder, and so raises the buckets of the pumps which are hung to the other end of the beam. The exhaustion regulator is now shut, and the steam one opened again, which by letting in the steam allows the piston to be pulled up by the superior weight of the pump rods; and so the engine is ready for another stroke.

The working of these engines is more regular and steady than the common ones, and from what has been said, their other advantages are apparently very considerable; but to say exactly how much they excel common engines, is difficult, as common engines differ very much among themselves. I am told, that the savings amount at least to two-thirds of the fuel, which is a very considerable object where coals are as expensive as they are in Cornwall.

The new engines will raise from twenty thousand to twenty-four thousand cubick feet of water to twenty-four feet high, by one hundred weight of good pit-coal: and I am informed, that Mr. Watt's improvements do not rest here; for he means soon to exhibit to the world engines upon the same principles, though differing somewhat in construction, which will use much less fuel than those described, and will also be more convenient for the purposes of Mining, than any kind of engine yet used.

He has also contrived a kind of mill wheel, which turns round by the powers of steam exerted within it; but as he has not made its structure publick, I cannot favour my readers with a description of it.

It



It may not be unacceptable to give a short history of the invention. These improvements were invented by Mr. James Watt, at Glasgow in Scotland, in 1764. He obtained his Majesty's letters patent for the sole use of his invention in 1768, and then made a larger machine than what he had formerly tried his experiments upon; but several mechanical difficulties occurring in the execution of the machine, and his attention being engaged in other business, he laid aside the undertaking until 1774, when he came to Birmingham, and in conjunction with Mr. Boulton, of Soho near that place, he completed both a reciprocating and a rotative or wheel engine. He then applied to parliament for a prolongation of the term of his patent, which was granted by an act passed in 1775. Since that time the business has been carried on by Mr. Boulton and him in partnership.

They have erected several engines in Staffordshire, Shropshire, and Warwickshire, and one small one near London. They have also lately finished another at Hawkesbury colliery near Coventry, which is justly supposed to be the most powerful engine in England. It has a cylinder fifty-eight inches diameter, which works a pump fourteen inches diameter sixty-five fathoms high, and makes regularly twelve strokes of eight feet long each in a minute. They are also now erecting three engines more in Cornwall, viz. at Ting Tang, Owanvean, and Tregurtha Downs: and have lately set to work a small engine at Huel-Buffy Mine, which has a cylinder thirty inches diameter, that works a pump of six inches and a half diameter in two shafts by flat rods with great friction, three hundred feet distant from each other, forty-five fathoms high in each shaft, equal in all to ninety fathoms, and can make fourteen strokes of eight feet long in a minute, with a consumption of coal less than twenty bushels in twenty-four hours.

The terms they offer to the publick are, to take, in lieu of all profits, one-third part of the annual savings in fuel, which their engine makes when compared with a common engine of the same dimensions in the neighbourhood. The engines are built at the expence of the users, and Messrs. Boulton and Watt furnish such drawings, directions, and attendance, as may be necessary to enable a resident engineer to complete the machine.







A N

# E X P L A N A T I O N

O F T H E

## C O R N U - T E C H N I C A L T E R M S A N D I D I O M S

O F

### T I N N E R S,

Including those which are used in the Lead-Mines and Collieries  
of GREAT-BRITAIN.

**A**  
**ACCOMPT.** Account, or Account-day—Either a monthly or any other day of meeting of the Mine-Adventurers; when they assemble together to adjust the charges of working the Mine, the particulars whereof are entered in a book called the Accompt-Book. The house of meeting, if on the Mine, is called the Accompt-House.

**ADIT, Tye, or Level.** A Sough in the north of England. An Adit, quasi, ab aditu ad aquas. (Carew's Survey). An Adit is a Conduit or Channel, begun on a valley or low ground at a distance from the Mine, and thence continued at the same depth or level home to the Mine, to cut in depth and drain off the water. Sometimes it may be brought home for the purpose before mentioned across the country, and at other times on the course of a Lode to prove it as they go. And at other times, for the greater ease and speed on the course of a Cross-Lode, Gossan, or branch, according as circumstances are favourable.

**ADIT-END.** The furthestmost end or part of an Adit from its beginning, or the very place where the Miners are working under-ground towards the Mine.

**ADVENTURE.** A Mine in working is so called, and so is the affair of being concerned in a Mine, as it is usual to say, "A person is about to take up an Adventure."

**ADVENTURERS**—Are those persons concerned in a Mine who have Doles, shares, or parts thereof. Out-Adventurers are those who contribute their quotas of the charge, but do not give

a daily attendance. But In-Adventurers are such who have Doles, and also work in or attend the affairs of the Mine for wages, or pay their cost by account for goods.

**AFTER-LEAVINGS.** See LOOBS.

**AIR-PIPE.** A wooden pipe or tube, one end of which is above-ground, and the other end reaches down to the bottom of the Shaft, so that the motion of the wind forces down air to the labourers.

**ALIVE.** That part of the Lode which contains Tin, Copper, or Lead, and is worth the saving and dressing for the furnace, in opposition to that part of the Lode which is dead or barren, and holds no Metal.

**ANVIL.** Cornish Anvon. A hard stone or any other thing on which they spal or break up the large stones of Ore for the better separation of their different kinds.

**ARCH, or Pillar.** A piece of the Lode or Country left standing up to support the Mine; the Arch being a Drift or hole broke through the pillar.

**ASSAY and ASSAYING.** The product in Metal of one ounce of Tin or Copper Ore, or the process for knowing the product of any other Metal or Mineral.

**ASTEL.** A board or plank. (Lhuyd).—Stull—An arch or ceiling of boards over the mens heads in a Mine, to save them from the falling stones, rocks, or scales of the Lode or its walls. To "throw the Deads to Stulls," is to throw the refuse part of the Mine on these arches or Stulls, both to save the trouble of bringing it up to grafs, and because this helps to make the Mine the more secure.—Stidalls. In Du Cange's Glossary of Latin Words, Astulla, or Hastulla,



**Haftulla**, signifies a chip or segment of wood cut off from a greater piece. (Vid. Pref. p. 15. Leland's Itinerary, vol. vii. 1769). **Stull**, a Bunding in Derbyshire.

**ASSISTANTS**. The commons or lower house of convocation or parliament of Tinnors. Each Convocator appoints his own Assistant, who is generally supposed to be a gentleman of veracity, integrity, and understanding in all Mining affairs. There are twenty-four Convocators, and twenty-four Assistants every convocation. See STANNARIES.

**ASTYLLEN**. A small ward or stoppage on purpose in an Adit or Mine to prevent the free and full passage of the water, by damming it up to a certain height, though not entirely to stop its current. Also, a kind of hedge or rude wall-work to separate Lode and Deads from each other when brought to grafs. Also, a hedge under-ground, as a wall to prevent the running of Deads.

**ATTAL**, Attle, Adall, Addle. Corrupt, impure, of no value, off-casts, Deads, or refuse parts of the working that the Miners find under-ground on reassuming an old Adventure; that earth also which moulders away and falls down to the bottom of the Shaft, or pit, is called Attal, and so is all the stony earth broke in Mining which is not of a veiny nature. (Wastrey or Deads in Derbyshire).

**ATTALL-SARAZEN**. Saxons or Jews off-cast. (Carew's Survey).

**AXLETREE**. A thick piece of timber in form of a cylinder with a large rope wound about it, and with which they bring up the work or Ore, and usually let the men descend and come up; but the windlass includes the axletree with its appurtenances, as layers, upstanders, stays, and brace boards—Defined—Stows in the north of England, which are seven pieces of wood (set up on the superficies of the earth) fastened together by pins of wood. Two are called Soul-trees; two Stow-blades; two Hang-benches; and a Spindle; these Stows give a Miner, or any person who owns them, as good right to a meer or meers of ground (so that every meer has a pair of Stows set on them) as a deed of conveyance doth to any purchaser.

**B**

**BACK**—Of the Lode. That part of the Lode which is nearest and uppermost

towards the grafs or surface. (The Roof, Derbyshire).

**BAL**. A shovel, a plague, a place of digging; Balas, To dig—Palas, idem. (Borl. Vocab.) When many people are employed in a Mine of note, in spaling, and sorting the Ore, where it is brought to grafs, then they stile this place where the concourse of people meet and work, by the name of the Bal, especially if the place be seated on an eminence, for they say, "A person is gone up to Bal;" but if the place or Mine lies low, it is usual to say, "He is gone to Moor;" if in the valley, they say, "He is gone to Coomb." Baly, signifies, To cast up.

**BAR**. Any course or vein which runs across a Lode or Mine is often termed a Bar; but they sometimes meet with a very hard kind of stone, called an Ire-stone, which forms a sort of course like as it were a Lode, but perhaps several fathoms wider: this is named a Bar. Bar-Master among the Lead Miners, is he which keepeth the Gage or dish to measure the Miners Ore, he or his servant being present when measured. (Houghton's Rara Avis, &c.)

**BARGAIN**. See FATHOM.

**BATCH**. A parcel or quantity of any thing. "A Batch of Tin"—"A Batch of Bread," &c.

**BEAT**—"away the ground." Signifying the working away on the course of the Lode: or the sloping away any ground in a Mine.

**BEU**. Alive. (Cornish).

**BEU-HEYL**. A live stream, i. e. rich for Tin.

**BINDER**—Or Timber-man, so called, who undertakes to bind and keep a Mine open, or prevent any part from crushing or falling together.

**BING**. See COBB.

**BLACK-JACK**. See MOCK-LEAD.

**BLACK-TIN**. Tin Ore, triturated, washed, and clean for smelting.

**BLOCK-TIN** or **WHITE-TIN**. Is Tin brought to its finest purity by smelting.

**BLOWERS**. The persons that melt Stream Tin with charcoal fires, excited by bellows worked by water wheels.

**BLOWING-HOUSE**. The house wherein the furnace for blowing is. (Blast-House in Derbyshire).

**BORIER**. An instrument of iron steel-pointed to bore holes with in large rocks, in order to blow them with gun-powder.

**BOTTOMS**. The deepest working parts of a Mine that is wrought either by sloping,



ing, driving, or otherwise breaking the Lode. (Bottom, Sole, in Derbyshire).

**BOTTOM-CAPTAIN.** A superintendant over the Miners in the Bottoms.

**BOTTOMS—in Fork.** When all the Bottoms are unwatered, they say, "The Bottoms are in fork;" and to draw out the water from them, or any Dippa, or any other particular part of a Mine, is said to be "forking the water;" and when accomplished, "Such Dippa, &c. is in fork." Likewise when an engine has drawn out all the water, they say, "The engine is in fork."

**BOTTOM-LIFT.** The deepest or bottom tier of pumps.

**BOUNDS and BOUNDERS.** Are limited parcels or pieces of land enjoyed by the owners of such Bounds. See book iii. chap. iii. page 137.

**BRACE.** Includes the spot of ground where the chief working Shaft of the Mine is, with the materials and implements thereunto belonging, as axletree, rope, &c. See AXLETREE.

**LAY DOWN AT THE BRACE.** If a person is desirous of relinquishing his Dole in a Tin Mine, he does so either by writing in the account-book, after having paid his cost to that time; or else he lays down, or declines his Dole at the Brace, by putting his hand on the axletree, and publicly declaring that he will be no longer concerned in the Mine.

This was an ancient custom, but it was observed only in Tin Mines; and how far it is lawful so to do, or binding upon the rest of the concerned, is matter of doubt.

**BRANCH.** A leader, string, or rib of Ore, that runs in a Lode; or if a Lode is divided into several strings, they are called Branches, whether they contain Ore or not: likewise strings of Ore which come transversely into the Lode are called Branches, and so are all veins that are very small, dead or alive, i. e. whether they contain Ore or not.

**BROOD.** Any heterogeneous mixture among Tin or Copper Ore, as Mundick, Black-Jack, &c.

**BRYLE.** See page 125.

**BUCKING and BUCKED ORE.** A method of breaking the poor foul Copper Ore smaller by hand with small flat irons, called Bucking-Irons, in order to wash and separate the pure Ore from the useless waste. The same term is used in the Lead Mines. But Pettus, in his Fleta Minor, gives it the signification of washing, or wet stamping Ores.

**BUDDLE.** Pits dug in the earth near the

stamping mill, seven feet long, three feet wide, and two and a half feet deep, where the stamped Tin is curiously washed from its impurities by water constantly running through the Buddle, while a boy, called a Buddle-boy, is standing in the body of it, and working both with a shovel and with his feet.

**BUNDING.** See ASTEL.

**BUNNY—Of Tin or Copper Ore.** A Sombrero in Alonzo Barba. A pipe of Ore. A great collection of Ore without any vein coming into or going from it.

**BUNCH or BUNCHY.** A Mine that is sometimes rich, and at other times poor, is said to be bunchy. We also say a rich Bunch of Ore; and if it is short, we say it is a Bunch.

**BURDEN.** The top, waste, or deads in stream works, that lie over or upon the stream Tin, which must be cleared away before they can work effectually. All waste covering of Tin, &c. which must first be removed, is called the Over-burden, Top-burden, or the Burden.

**BURROW.** That heap, or heaps of attle, deads, or earth (void of Ore) which are risen out of a Mine, and commonly lie around the Shafts. Any heap or hillock of deads or waste.

**CAPLE.** A sort of Stone something like a Limestone, but will not burn. The walls of most Lodes are of this kind of Stone, therefore it is common to call the wall of a Lode, by the name of its Caple. Also some veins which abound with this Stone, are termed Caples, or Caple Lodes.

**CAL.** (It signifies in Cornish, Cunning, Lean). Properly, Gal. A kind of Iron Gossan Stone found in the Bryle and backs of Lodes, much of the colour of old Iron, reckoned a poor brood with Tin; therefore it may be so applied because it impoverishes the Lode and destroys the fatness of the Metal. (See Gal). It is termed Wolfram by Cronstedt, and defined a kind of Manganese.

**CALK.** Cornish, for Lime.

**CALLYS.** (Cals, Calish, Cales, ac idem, Callys,) Killas. (Cornish) Hard; smart. The most common and agreeable Stratum in our Mine country, usually called Killas, (Killow, by Woodward). Of the many sorts of this Stratum, see book i. chap. i. I believe  
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this to be the proper name for Killas, as it means a hard firm Stone.

**CAPTAIN.** An experienced Miner, who directs and oversees the workmen and business of the Mine.

**CARN.** A rock. A heap of rocks. A high rock. The stony Stratum.

**CASED TIN.** That which is reframed by the gentlest current of water, and prevented from running off the frame by turf placed at the bottom.

**CASES.** Probably a corruption of Chasm.

Very small fissures in the strata of the earth, through which small streams of water flow when they are opened by working under-ground, greatly to the hinderance of the workmen, &c.

**CAST after CAST.** Is throwing up of Tin-stuff, &c. from one stage of boards to another, each cast about five or six feet high.

**CAST of the COUNTRY.** See COUNTRY.

**CASUALTIES.** See LEAVINGS.

**CAUNTER and CAUNTING.** Contra. When two Lodes run across, the one, or either of them, with respect to the other, is called a Caunter or Contra, for they run caunting, or contra-ing each other. As all Lodes which run cardinally east and west, go through every kind of vein except Cross-Gossans, I define such to be Caunters.

**CHARGE.** Any quantity of Ore put at one time into a furnace to fuse, they call a Charge. Letting it out, they call "Tapping the Charge."

**CHOAK.** An Adit is said to be choaked when any earth or stone falls in and prevents the current of the water through it. The place or part so filled, they call "The Choak."

**CLACK.** The valve of the pump piston. The Can-lead, in Derbyshire.

**CLACK-DOOR.** A square iron plate screwed on to the side of a bottom pump or small bore, for convenience of changing the Clack, or valve.

**CLEARING—The Deads, Clearing a Shaft or Drift, &c.** When any part of a Mine or Drift is filled or incommoded by Attle or Deads, the removal of such is called "Clearing the Deads," "Clearing of Attle," or the like. In old workings it is the first thing to be done, and in the north they term it, "Clearing the old man."

**COB.** (Dho Cob, Cornish). To break or bruise. A Cobber, a bruiser of Tin. Cobbed Ore is the spalled which is broke out of the solid large stones with sledges, and not put to water, being usually the best of the Ore; the same as

Bing Ore in the Lead Mines. Nocking, Derbyshire.

**COCKLE.** The Skiorl of the Swedes, and the Schorl of the Germans. Anglicè, Shirl, (Cronstedt). A laminated Mineral substance of a blackish brown colour like Tin, often intermixed with it, and taken for it, to the frequent detriment and disappointment of the Tanners. Cockle is a Weed in Cornish; whence, a Weed or Brood in Tin. See Pope's Glossary to Shakspeare.

**CÔFER.** (Côfar or Kopher, Cornish, a Chest). A small wood trough under the frame, which receives the Tin cleared from its impurities or slime.

**COFFIN.** Old workings which were all worked open to grass, without any Shafts, by virtue of digging and casting up the Tin-stuff from one stage of boards to another. Workings all open like an intrenchment.

**COKE.** Charred pit-coal.

**COLLAR—"of a Shaft,"** is the timber and boards which secure the uppermost part of a Shaft in the loose rubble from falling in.

**COOMB.** See BAL.

**CONVOCATION and CONVOCATORS,** or Parliament of Tanners. All stannary laws are enacted by the several convocations, and carry with them all the force and law of acts of parliament. A Convocation is but too seldom held, to the disgrace of the county and the injury of the Tinner; for the laws now in being are very weak, contradictory, and inconclusive. See ASSISTANTS and STANNARIES.

**CORE.** (i. e. Corps; body, company, society. French. Boyer's Dict.) Corps is used among the military, and pronounced Core. With the Tanners it has also a respect to time, such as their proper change or turn of working. Thus it is said, the first Core by night is eight o'clock, for instance; the second Core is four after midnight, and the day Core commences perhaps at noon-day, according as the labourers will settle among themselves. But in difficult and hard working places, where water is too troublesome, or air is very deficient, they divide their Cores into four; that is, every six hours. In such case, they relieve upon the spot; for at the known hour, fresh men come under-ground, and take the tools from them who have just finished their working time. See DAY-PAIR.

**COSTEAN.**



**COSTEAN.** (From Cothas, to find; Stean, Tin; or Dropt-Tin. Cornish). Costean pits, are shallow pits to trace or find Tin. Costeaning, ditto.

**COUNT-HOUSE.** (Reckoning-House, in Derbyshire). A house or room on the Mine, wherein the Adventurers and their agents transact the business and keep the accompts of the Mine. See ACCOMPT.

**COUNTRY.** The Strata of the earth. When Miners drive an Adit out of the Lode or vein in the solid Strata, they say, "They are driving in the Country;" so if they sink a Shaft to cut a Lode, they are said to be sinking in the Country until they come to the Lode. Likewise, an Adit or Drift which is driving north or south, is "across the Country." Also, the similarity of the Strata for some continuance, is denominated "The run of the Country" and "the east of the Country."

**COURSE.** Any vein or Lode is often termed a Course. A Tin-Course. A Copper-Course. A Cross-Course. And the phrase of "Working on the Course of the Lode," implies to work along on its direction or length; but when it is said, "A Mine is in full Course of working," the meaning is, that it is fully occupied; so, likewise, when it is said, "The men keep a due Course of working," it signifies, they duly mind their labour.

**CREAZES.** The work or Tin in the middle part of the Buddle in dressing, viz. the head or fore part of the Buddle, the Creaze or middle, and the tail or last, though some call that the Hind-Creazes.

**CROP.** Ore or Tin of the first quality after it is dressed or cleansed for smelting. The finest black Tin is called the Crop, worth, at a medium, one for two; i. e. forty pounds of such black Tin you may exchange for twenty pounds of Block-Tin, called White Tin. The second sort is called Rows, a corruption of Roughs, being poorer and larger in size; saleable at six for twenty.

**CROSS.** Cross-Course. (See BAR, COURSE). Cross-Bar; Cross-Gossan; Cross-Lode. Is either a vein of a metallick nature, a Cross-Gossan, or else a soft earth, clay, or Flookan like a vein, which unheads and intersects the true Lode. (A cross vein in Derbyshire).

**CUARE.** (Cornish) A quarry of stones.

**CUT.** To intersect a vein, branch, or Lode, by driving horizontally or sinking

perpendicularly at right angles. "I cut the Lode at twenty fathoms depth." "I cut the north branch in driving ten fathoms." "We cut a large stream of water in the Adit-end."

D

**DAMP.** (Dampff, Teutonick). A vapour, or pernicious Halitus, from or in the bowels of the earth. A want of circulation of air under-ground.

**DAY.** Ore is said to be discovered near the Day, when it is found near the surface.

**DAY-PAIR.** Are those who work underground by day; and Night-Pair, vice versa. See CORE.

**DEADS.** Any thing that is broken underground unmetallick, or not worth the saving; in opposition to that part of a Lode which is rich for Metal: therefore Lodes which are unmetallick, are called Dead Lodes.

**DERRICK.** (Cornish) A Sexton, a Digger, a Miner. (Nomen Familiæ).

**DIALLING.** Is the method of taking a traverse under-ground by the compass, so that by laying out the same above-ground, they find where an Adit-end is; or the end of any other drift or working, in order to sink a new Shaft on it perpendicularly. Also, by Dialling they find the just limits of their ground underneath, to know if it corresponds with their limits above, &c.

**DILLUEING.** (Dilleugh, To let go, let fly, send away. Dylr id. Cornish). A method of washing or finishing the dressing of Tin in very fine hair sieves, called Dillueing sieves or Dilluers.

**DIPPA.** (A pit, Cornish). A pit or hole sunk in a Lode by way of a little sumph to collect water to draw out by small barrels; also a pit sunk in a bunch of Ore, which is a very irregular and ruinous way of working a Mine. The Tanners say, "It is eating the calf out of the cow's belly."

**DISH.** That part of the Ore or sterling poundage, which the Lord or owner of the fee reserves to himself, free of all charges, in consideration of the liberty he grants the Adventurers to dig and search for Metals, or occupy the Mine. The Dish is also stiled the Lord's Dues, (See BOUNDS, FARM, SETT, and TOLL). In the Lead Mines, a Dish is a trough of wood twenty-eight inches long, four deep, and six wide, by which they measure that part of the Ore which is called



called the Lord's Lot—and, no doubt, this was the method formerly used in Cornwall, from whence the Lord's Dish is a term now in use.

Dish is the ancient name of a measure used for black Tin, containing a gallon. (Carew). "Dishes or bowls are measures filled with Ore by the Miners, whereof, some are paid to the king, others to the church," &c. (See Pettus, on the word Metallick).

DIZZUE. (From Dyz-hui, to discover unto, Cornish). To Dizzue the Lode, is this: If it is very small and rich, they commonly only break down the country or stratum on one side of it, by which the Lode is laid bare, and may be afterwards taken down clean and free from waste. To Dizzue the leader of a Lode is much the same thing; for if there is a side or part of the Lode better than the rest, but not a Working Big, they keep the best part separate and let it stand in its place, until they first break and remove the poor part; afterwards they break the Dizzue or best part, and reserve it to be separately handled and dressed: thus the good Ore is dressed with less charge, and proves better in value than if it were promiscuously with the poor Ore. (See HULK). The refuse or deads of a Dyzhued Lode, is called in some places, "The Dyzha."

DOAR. (Cornish. The earth. An Oar, idem) Whence Ore, the earth of Metals.

DÔL. (Irish, Daal; Saxon, Deald, divided, see Verftegan; Cornish Dôl.) Any part or share of the Adventure or Tin Ore, as one-eighth, one-sixteenth, one-thirty-second, or the like. "Anciently where a meadow was divided into several shares, it was called a Dôl-meadow." Jacob's Law Dictionary.

DOL. Pronounced Doll, is Cornish for a valley or dale. Dol-côth, the old field or meadow. Dol-côth, the old valley or dale. The name of a great Mine in Camborne, Cornwall.

DOUBLE-PICK, DOUBLE-MEN. Is when two men are allowed to attend one pickaxe by day, and as many by night, if needful, so that the pick is kept constantly at work.

DREDGED—Ore. See Powdered-Ore.

DRESSER. Any person who superintends the boys at stamping mills; or men, boys, and girls in the Copper Bals, commonly called Pickers, Cobbers, and Jiggers. The man that directs the various manuductions and lotions of Ore for sale, is called the Dresser.

DRIFT. Is the level that the men drive under-ground from one Shaft to another, from one Winds to another, or north and south out of the Lode, in which, only one man at a time can work, it being but a working big, and about five or six feet high. In the northern counties this is called a Gate; a Way-gate; a Waggon-gate.

DRIGGOE or DRIGGER. The lower pump of the set or tier of pumps belonging to a water engine. See TIER.

DRIVE. To drive is to work in a Drift, so that if you drive or work on straight in a Lode or in the country, the vacant passage behind your back is the Drift. To cut, in Derbyshire. See DRIFT, see CUT.

DRY. See VAT.

DUES. See DISH.

DUMB'D. When Tin or Copper Ore is stamped under size or too small, it is apt to choak the grate, or flow away with the water in dressing, then they say, "It is Dumb'd."

DURGY. A small low hedge of turf. Any thing low or short. "A Durgy-man or woman."

DURNS. Frames of wood like the jambs of a door or the frame of a window, commonly set in loose ground in Adits and places that are weak and liable to fall in or tumble down. (Forks and Sliders; Stop Rods and Grove Timbers, in Yorkshire. Piers and Pairs, in Derbyshire).

## E

ELBOW. A Lode makes an Elbow thus ~ when it is pressed or squeezed by hard Strata or rocks which cause it to deviate from its true course or direction, making an obtuse angle and small turning, though seldom disordered in any other respect.

ELVAN. (Elven, in Cornish, an element, a spark of fire). A very hard close grained stone, thought to be a bastard limestone; but I do not find that it has any calcarious quality. A very unpromising Stratum for Copper Ore.

END. An End is the furthestmost end or part of an Adit, or any other Drift from its beginning, or the actual working part of a Drift or Adit. (A Stool and Forefield, in Derbyshire. Forehead, in Yorkshire).

ENGINE. A machine to unwater Mines. Those which are worked by water, are termed Water-engines. Others which perform



perform their office by fire, are Fire-engines. There are other forts called Horse-engines. The persons who undertake to erect and take care of them, are called Engineers.

# F

**FARM.** That part of the Lord's fee, which is taken for liberty to work in Tin Mines only, that are bounded, which is generally one fifteenth of the whole. See BOUNDS, DISH, SETT, TOLL.

**FAST.** The firm rock or stone unmoved by the deluge, which lies immediately under the loose rubble.

**FATHOM.** Six feet in height, depth, or length. All work in the Cornish Mines, is generally performed by the fathom; such as stoping, driving, and sinking.

**FEASIBLE-GROUND;** is Ground that can be speedily wrought, and yet will stand without the support of timber and boards.

**FIRM.** Firm shelf. See FAST and SHELF.

**FISSURE** or **GULLY;** is that crack or split in the Strata of the earth, which is the receptacle of mineral particles, whose contents are stiled a Lode.

**FLATS** or **FLAT-RODS;** are horizontal rods or poles fixed by a semicircular wheel to the perpendicular rods of a fire or water engine, by which the piston in a pump at some distance from the engine draws water.

**FLOOKAN.** An earth or clay of a slimy glutinous consistence; in colour, for the most part, blue or white, or compounded of both. A Cross-Flookan runs across through a Lode, unheads it, and throws it on one side out of its place. There are Flookans also which run parallel with metallick Lodes, and take the name of Course-Flookans. Some metallick Lodes abound with a large part of this clay on either or both walls of the Lode; and when it is throughout the vein, it is called a Flookan Lode. A small slide is also a fissure filled with clay or Flookan. See SLIDE.

**FLOOR.** A Floor is a bed of Ore in a Lode, though supposed not to continue to any great depth or time; therefore is a Stratum of Ore.

**FLORAN.** Is an exceeding small grained Tin, scarce perceivable in the stone, though perhaps very rich. Also, any Tin which is stamped exceeding fine, and underize, is called Floran Tin—quasi, Flower Tin.

**FOGE.** (Cornish) A forge or blowing-house for smelting of Tin.

**FOOT.** An ancient measure for black Tin, two gallons; now a nominal measure, but in weight 60 lb.

**FOOTWAY.** In shallow Mines, the common way of going down is by a rope or windlafs: but in deep Mines, they have old Shafts with ladders in them, and landing places at the foot of each ladder called a Saller, by means of which they descend into the Mines; whence this is stiled the Footway; and those Shafts, when applicable to no other use, Footway Shafts. (Waygate and Climbing Shaft, North of England).

**FORCER.** A small pump worked by hand, used in sinking of small Sumphs, Dippas, or Pits.

**FORCQUE,** Fork; the bottom of the Sumph. Forking the water, is drawing it all out; and when it is done, they say, "The Mine or the water is Forked;" and "the Engine is in Fork." The Forcque or bottom of the Sumph in the North of England, is called the Lodge; Forking the water, "Rolling the water;" the Engine in Forcque, "the Engine in rowl."

**FRAME** or **RACK;** composed of two planes of boards a little inclined, over which runs a very small equable stream of water to wash off the fordes from slime Tin, &c.

# G

**GAD.** (Gedn is Cornish for a wedge; Gad an iron wedge; Gad is Armoric for a Hare). A Gad is an iron wedge to drive between the joints of rocks, in order to loosen the ground for the pickaxe.

**GAL.** The proper name for Cal. Gal signifies rust and rusty in Cornish; and, accordingly, Gal, usually pronounced Cal, is a Gossany, or rusty Iron Ore. Kal is a false word for it, that term signifying Phallus; Membrum Virile.

**GANGWAY.** When a Fissure or Lode is excavated in the backs or former upper workings of the Mine, it is saltered with boards, and the deads are thrown there, which they also call Stulls: however, if they leave room sufficient for the workmen to roll stuff, or walk upon them from one Shaft to another, they call it a Gangway. Gang, in the Teutonical, signifies a Vein; but it is a sea term also.

# N n n n

# GATCHERS.



**GATCHERS.** The after leavings of Tin.  
See **LOOBS**.

**GLIST.** A shining black or brown Mineral of an iron cast, somewhat like Cockle.

**GOSAN.** A kind of imperfect Iron Ore, commonly of a tender rotten substance, and red or rusty iron colour. It is often found shallow in Tin, Copper, and Lead Mines, and is the proper Nidus or Matrix for the two latter. It is an upper covering to the Ore, levels above thirty fathoms, and is very abundant; whence those Lodes are called Gosan Lodes.

**GOUNCE.** See **STREKE**, and the chapter on Stream Tin.

**GRAIN TIN.** The Ore of Tin that is sometimes dug very rich in the form of grains or pebbles, or else in larger pieces, composed of many such distinct grains, united in one entire mass, always of a black or dark rosin colour, pointed like diamonds. Also, the purest and finest block or white Tin, smelted with charcoal in the blast or blowing-house furnace, which never had any brood or foreign mixture in the Mine. Grain Tin is peculiarly produced from stream work, and is worth several shillings  $\pounds$   $\pounds$  more than Mine Tin.

**GRANT.** See **SETT**.

**GRASS,** or at **Grafs**, signifies on the surface of the earth. "Is Tom Treviscas "under-ground? No; he's at Grafs." A Grafs Captain is an Overseer of the workmen above-ground, as the bottom or under-ground Captain superintends his men down in the Mine.

**GRATE.** An iron plate punched full of small holes; which belongs to the stamping mill, and sizes the stamp Ore, because it must all pass through these holes by a small stream of water.

**GREUT** or **GRIT.** A kind of fossil body, of sandy rough, hard, earthy, particles.

**GRIDDLE.** A large wire sieve, used instead of a hurdle, for sifting and sorting of Copper Ore, as it rises from the Mine. Erckern calls it a Ratter, or Riddle, Screen or Sieve, to separate the clean from the unclean Ores before they come to the fire. "This instrument doth "unriddle them by separation: and for "the word screen, it is doubtless from "secernere to divide, and sieve from "segregare or sever." Pettus on the word metallick.

**GROUAN.** (Grou, Cornish) Gravel, rough sand. Grouanen, a pebble. Hard Grouan is Granite or Moorstone. (Gronsten, Swedish) Soft Grouan is the same materials in a lax and sandy state.

Grouan Lode, any Tin Lode which abounds with this gravel. Grouder, a mixture of Grouan and clay, much used for scouring of timber-ware in house-wifry.

**GROUND.** (See **COUNTRY**, and **SHUT**). We say, a hard rock or Stratum is "Hard Ground." On the contrary, soft clayey Ground they call "Fair Ground;" and if fair, yet firm to stand without timber, "Feasible Ground."

**GUAG.** (Hunger, emptiness; ac idem, Leary, Cornish). Tinnerns holeing into a place which has been wrought before, call it "Holeing in Guag."

**GULPH OF ORE.** Where a Lode throws up very great quantities of Ore, and proves lasting and good in depth, they say, "They have a gulph of Ore."

**GUNNIES**—means breadth or width. A single Gunnies is three feet wide; a Gunnies and a half is four feet and a half; and a double Gunnies is six feet wide. The former vaults or cavities that were dug in a Mine, are termed "The old Gunnies;" and if they are full of water, they are sometimes called "The Gunnies of water;" yet more commonly "A House of water."

**GURT.** A fret or channel made by great rain or floods in a highway; also, a channel to carry off water from one place to another for dressing of Copper Ore, Tin, or the like. Gurt, in Cornish, implies large, great. "Gurt "Mawr of Vufs," Great root of furze.

## H

**HALVANS, HALVINGS, HANAWAYS.** All which names imply the refuse Ore, or the poor Ore and Stone after the prime Copper Ore or Crop is first taken out; but they often cull over these Halvans again, and take more Ore out of them, which is called Halvan Ore. (Halvans, waste hillocks, North of England). The poor refuse part of Tin-stuff goes not by this name, but that of Leavings, or Casualties.

**HEADS.** See **STAMP-HEADS**.

**HEAVE.** See plate of Heaves in Goonlaz, &c. and book ii. chap. iii.

**HEWNS.** The sides of a calciner or burning-house furnace, from their being formerly built with hewn Moorstone.

**HOGGAN.** In Cornish signifies a Hawthornberry; also, any thing mean or vile: but here it means a Pork Pasty; and now indeed any Tinner's pasty that he carries



carries to Bal with him, is called a Hoggan.

**HOLE.** To hole, is to make a communication through one part of a Mine to another. To hole a Shaft, is to sink it through into the Mine or hollows.

**HOOKHANDLES,** are the handles of the turn or windlafs for winding up the work from underground. (The Sweeps, North of England.)

**HORSE.** A portion of dead ground in a Lode, which widens like a horse's back from the spine. (See plate of Bullen-Garden Mine, fig. 57.) A Rider and a Rither in Yorkshire.)

**HOUSE.** See GUNNIES, and TURNHOUSE.

**HUEL.** A Work, a Mine; as Huel Stean, a Tin Mine: Huel Kalish, the hard work.

**HULK.** An old excavated workings. "To hulk the Lode," is this: when the Lode is very wide, and only one side of it is rich for Copper or Tin, but much softer and more fair than the other poor part of it, they hulk in with their picks as far as they can upon the rich tender Ore, and leave the hard unmetallick part of it to stand by itself, which they afterwards blast by gunpowder, or otherwise break down and throw away. See DIZZUE.

**HURDLED ORE.** That which is sized by passing through a hurdle, like earth for mortar.

**HYRLIAU.** (Hurling, Cornish). A Cornish custom of playing with a ball. Hyrliau yu ghen guare wyi — Hurling is our sport. The ball is generally plated with Tin or Silver, and has usually a Cornish motto alluding to the play, as "Guare wheag, yw Guare teag; that is, Fair play, is good play."

I

**JETTERS.** See POKKERS and JETTERS. See FLATS.

**JIGGING.** Is a method of dressing the smaller Copper and Lead Ores by a peculiar motion of a wire sieve in a kieve or vat of water, where the smallest particles pass through the Jigging-sieve, and those which are larger and solid lie at the bottom of the Jigging-sieve or Jigger; so that the uppermost light stony waste may be easily separated and skimmed off by a piece of semicircular board, called a Limp. In the Lead Mines, the Jigged Ore goes by the name of Peasy; and they also term this operation, "Setting in the Sieve," and "Washing."

**INFECTION.** (A BROOD, which see). Any heterogeneous Mineral mixed with Tin or Copper Ore.

**IRESTONE.** Takes not the name from its participation of Iron, though there is some Iron in it, but from its excessive hardness. Its colour is a bluish grey, and sometimes it runs several miles, keeping its course on directly like a Lode. Being very difficult to work and break through, it is therefore often termed an Iron Bar, or a Bar.

K

**KAL.** (See CAL and GAL). Kal. A Phallus; Membrum Virile. Llhwyd. Kalish, hard.

**KAZER.** A sieve.

**KERNED.** A heap of Mundick or Copper Ore will harden by lying exposed to the sun, when they say it is kernalled.

**KERNOU.** Cornwall. Kernuak, Cornish.

**KIBBAL.** (A bucket, a little tub. Armor. Quibell, idem). A Kibbal is the bucket in which all work or Ore is raised out of the Mines. Gear barrels, in the North of England. A Whym-Kibbal is a larger one, which belongs to the machine called a Whym, and serves to draw water with, or bring up the Ore to grass. Some of those larger barrels or Kibbals contain 120 gallons when they are intended for drawing of water out of the Mine.

**KIEVE.** A vat or large iron-bound tub for washing of Ores, &c.

**KILLAS.** (See CALLYS) Woodward says, "We call any stone Killas that splits with a grain," p. 6. Killas, plate, in Yorkshire, &c.

**KIVULLY.** Loose, hollow, shelfy ground.

**KNOCKING.** See COB.

L

**LANDING-PLACE;** the place where they cast the work out of the Kibbal, contiguous to the working Shaft, which they also term the Landing Shaft, being a Whym Shaft.

**LAPPIOR.** (Cornish). A dancer. See book iii. chap. ii. pag. 136.

**LATHS.** Are deal boards pointed at one end, for driving between durns or frames of timber and loose deads, in that manœuvre called "Shutting of attle;" they are called Laths, from some resemblance to laths for plaistering.

**LAUNDERS.** Troughs of deal boards to save the water, and prevent its falling down



down into the bottoms; also, to convey water across Shafts, Drifts, and Gunnies, and for conveyance to any place for driving engine or mill wheels.

**LAYER**—and laying of Tin. See **SERVING**.

**LEADER**. A branch, rib, or string of Ore, that leads along to the Lode; or else if it be in the vein, and points, or leads away, so that they hope for a parcel or bed of Ore by following it, then this string is a Leader or Guide; moreover when they purposely drive on, and follow veiny natured strings, though without any Ore or life in them, yet such are Leaders to follow. See **LODE**.

**LEARYS**—or lear; emptiness. Old men's workings. Vide Glossary Pope's Shakespeare.

**LEAT**. A water course, or level for conveyance of water, to engine or mill wheels.

**LEAVINGS**—or Casualties, in Tin, is the same as hanaways of Copper or Lead Ores, both being gleanings: but it rather implies the very minute Tin, that flows away with the water, in dressing the crop or prime Tin; but being gathered together is redressed to cleanse it from its impurities and slime, &c.

**LEVELLING**—and Levels. The art of finding a true Level to convey water from one place to another, or else to find the Level or depth of an Adit at a prefixed place.

**LIFE**—ac idem, Alive; which see.

**LIFTERS**—are solid pieces of ash timber 8 or 9 feet high, shod with iron stamp-heads for pounding the Tin-stuff, &c.

**LITTLE-WINDS**. (A sump in some parts of England) An under-ground Shaft, sunk from a horizontal drift, by which the top of the Winds communicates with the side or bottom of the grafts working Shaft.

**LIVER**—or ly-very stone. A hard liver-coloured stone, and in a Lode is very hurtful.

**LODE**. (Main Rake, N. England) The word Lode is an old Anglo-Saxon word, idem ac, Lead; so Lode-stone, quasi Lead-stone: see Lye's edition of Junius ad verbum. Any regular vein or course, either metallick or not; but more commonly it means a metallick vein: and being occupied and proving good, may indifferently be called a Lode, Mine, or Work.

**LODE-PLOT**. A Lode that underlies very fast or horizontal, and may be rather called a Flat Lode.

**LOFTY TIN**—in contradistinction to Florian Tin, for Lofty Tin is richer, mas-  
sive, and rougher, and not so weak or

imperceptible in the stone, or in powder on the shovel.

**LOOPS**. Tin slime or sludge of the after leavings, or leavings slime.

**LORD OF THE LAND OR FEE**. The person in whose land the Mine is; therefore, the part which he reserves to himself for liberty to work a Mine in his land, is the one-sixth, one-seventh, one-eighth, or any other proportion free of expence, and called the Dues, Dish, which see.

**LOST-SLOVAN**. (Lost, a tail, a rump, Cornish) Vulgo, Low-slovan; the beginning of an Adit, though the tail or end; that part which lies open like a trench, before they drive under-ground.

## M

**MAD-WATER**. Water that has been drawn from a Shaft, or any part of a Mine, and returns back again to the same place from whence it was drawn, is called Mad-Water, and implies a great want of skill in the managers.

**MATERIALS**. All tools and tackle, timber and implements, that belong to a Mine; and in large Mines a person is appointed to take care of them, who is called the Material-Man.

**MEAT-EARTH**—Soil; the superficial earth, fit for agriculture.

**MOCK-LEAD**. Wild Lead, black Lead, black Jack. A ponderous black Mineral, which does not readily incorporate in the fire. A Zinc Ore.

**MOOR**. (See **BAL**) This word signifies a root, or a quantity of Ore in a particular part of the Lode; as "A Moor of Ore." "A Moor of Tin."

**MOORHOUSE**. A hovel built with turf for workmen to change cloaths in. A Coe, Derby.

**MOORSTONE**. See **GROUAN**.

**MUN**. Any fusible Metal; unde Dunmwyn, a hill of Metals; unde Dunmuni, the Cornish Britains.

**MUNDICK**. An exceeding ponderous Mineral, whitish, beautiful, and shining, but brittle. Pyrites; Marcasite, &c. too well known for description here.

## N

**NEEDLE**. A piece of stout iron wire, used to make a touch-hole with in blowing of rocks with gunpowder. A pricker, Yorkshire.

**NIGHT-PAIR**. See **DAY-PAIR**, and **CORE**.

**NOCKING**. Knocking. See **COB**.

OLD



O

**OLD MEN'S WORKINGS.** See LEARYS.  
**ORE.** Earth. (See DOAR) Round Ore; rough, or Row Ore; straked, stamped, bucked, jigged, and slime Ores; which see.  
**ORE-PLOT.** (See PLOT) The Ore Plots at grafs; where they keep apart the dressed Ore for sampling, &c.  
**OWNERS.** See ADVENTURERS.

P

**PACKING.** A further or final dressing of Tin or Copper Ore, by putting of either in a kieve or vat with water, often stirring the water, and striking the sides of the kieve, by which means the heavy particles sink to the bottom, and the light waste swims uppermost; which is afterwards skimmed off, and thence called the Skimpings; which see.  
**PAIR.** Any indeterminate number of Miners who work together in a Mine in a Pitch upon Tribute, in a But-Bargain, &c. Also, they call any number of horses, from five to twenty, a pair of horses. See CORE and DAY-PAIR.  
**PARCEL.** A parcel of Ore, is a pile or heap of Copper dressed for sale.  
**PEACH.** Peach-Stone, a bluish green soft Stone. When a Lode is mostly composed of this sort of Stone, it is called a Peach or Peachy-Lode.  
**PEDNAN.** Pedn or Pen. (Cornish). A head or promontory. In Mine affairs, the Pednan is the head of the buddle where Tin is dressed.  
**PICK.** The common name of a Tinner's pick-axe; also, to pick or cull the good Ore from the bad by hand; whence those who do it, are called Pickers.  
**PILE—Of Ore.** A heap of Ore; a parcel of Ore; and sometimes a Dole of Ore.  
**PILLAR.** An upright piece or part of the Lode left to support the incumbent weight.  
**PILLION.** The Tin which remains in the scoria or slags after it is first smelted, which must be separated and remelted.  
**PIONEER.** An able Pickman or underground Tinner.  
**PIPE.** See BUNNY.  
**PIT.** A Shaft, Dippha, Sumph, or Cof-tean Pit; all Pits of different depths.  
**PITCH.** Any part or portion of a Mine, being a few fathoms in length on the course of the Lode, is so called: and if granted to the Miners for raising the

Ore at so much out of the pound sterling, it is called, "A Pitch upon Tribute;" if it is higher up in the Mine at a shallow level, it is called, "A Pitch upon the Backs;" and lower down, "A Bottom Pitch."  
**PLOT.** (Vulgo, Plat). "To cut a Plot," is to make room, or square out a piece of ground by the side of the Lode or Shaft, for holding the broken work or deads before they are brought to grafs; or for other convenient purposes. (A Plot, a Brigging-place in Derbyshire).  
**PLUMP.** A corruption of the word Pump.  
**PODAR.** Rotten, corrupt; Mundick—Copper Ore was formerly called Podar.  
**POKKERS and JETTERS.** Are blocks or pullies, over which the sweep rods of some engines move and play. (See FLATS). Pokkia (Corn.) unde Pokker, to thrust, poke.  
**POL-RÔZ.** (Pol, a pool; Rôz, a wheel, Cornish). The pit under a mill-wheel; the wheel-pit.  
**POL-STEAN.** (Pol, a head also; Stean, Tin. Cornish). A Tin pit. A miry head. (Carew).  
**POWDERED.** Powdered Ore. When a Lode is spotted with Ore, or stones of Ore, but in so disseminate a quantity and appearance as to be scarce worth the charges of dressing, they say, "It is Powdered Ore, or Dredged Ore."  
**PRIDE—Of the Country.** When Ore is found near the surface, at a level where it is rarely met with, and in great abundance and very rich; also, when a bunch of Ore is found out of a Lode like stones scattered in a quarry, they say, "It is the Pride of the Country."  
**PRYAN.** (From Pryi, Clay, Cornish). Pryan Ore, Pryan Tin, Pryan Lode; that which is productive of Copper Ore or Tin, but does not break in large solid stones, only in gross pebbles, or sandy with a mixture of clay.  
**PUPPY.** The set or tier of pumps below the Lilly underground.  
**PURSER.** A person deputed to keep and adjust the accompt-book, to receive the costs, and discharge the demands on the Mine; usually, both treasurer and secretary of a Mine.

Q

**QUAREY.** When a Lode or Stratum breaks in large hard rocks, being jointed as it were, it is called a Quarey Lode or Stratum, from its joints or Quâres.

O o o o

QUARTS.



**QUARTS.** A hard, opaque, and sometimes semi-transparent crystalline stony mass, vulgarly called Spar, which it is not, being a chrystalline basis. It is common in all our Lodes, some being little else. It is very plenty on our barren heaths; and is useful only for hedging and paving the streets.

## R

**RABBAN—Stone.** A yellowish dry stone, resembling Goffan.

**RABBLE.** An iron rake for stirring and skimming of Copper Ore in calcination and smelting.

**RACK.** See **FRAME**.

**RAFFAIN.** Raf. Raffain Ore; poor Ore of no value.

**RAG-PUMP.** A chain pump.

**RAKE.** See **RABBLE**. A true vein or Lode. (North of England).

**RAMMING-BAR.** A beater. (North of England).

**RED-RABB.** Red Killas.

**RELIEF—Time.** See **CORE** and **DAY-PAIR**.

**RENEWING.** See **TOLLUR**.

**RIB—Of Ore.** A leader, branch, or string of Ore.

**RIDAR.** A sieve. (Cornish). A Riddle. See **GRIDDLE**.

**RID—up a Shaft.** To clear it of the deads or attle fallen into it.

**RISE—in the back.** To work upwards towards the surface.

**ROD—Shaft.** An engine Shaft; because of the straight Rods which go down in the Shaft, and are fixed to the pistons of the pumps.

**ROOF.** See **BACK**.

**ROUNDHOUSE.** The vortex or round of a whym or engine race if hedged about and covered, is called the Roundhouse.

**ROUGHS.** Vulgo, Rows. See **CROP**.

**RÔZ.** A wheel. Graver-Rôz, a wheel-barrow.

**RUN.** To “run from a Bargain,” is when a Pair or set of men undertake a piece of work, and quit it before it is quite finished. “Run of the Lode,” is the course or direction of it. “Run of the Country,” see **COUNTRY**.

**RUNNING—Tackle.** See **TACKLE**, **AXLE-TREE**, and **BRACE**.

**SALLER.** Solarium, (low Latin) a garret or chamber. Soler, (Cornish) a ground

room, an entry, passage, or chamber. Sol, is a foundation. A Saller, in a Mine, is a stage or gallery of boards for men to stand on and roll away broken stuff in wheel-barrows—a Bunding, in Derbyshire. There is also another kind of Saller in an Adit, being boards laid hollow on its bottom, by means of which air is conveyed under feet to the workmen; this is called the Adit Fang, in Derbyshire. In a footway Shaft, the Saller is the floor for a ladder to rest upon.

**SAMPLE.** The taking certain portions of Tin or Copper Ores to assay or try the value of by fire or water, they call, “Taking a Sample;” the person employed are named Samplers; and the business itself Sampling. See **TICKET-ING**.

**SCAL.** A corruption of the word Scale. When a part of the wall or side of a fissure falls away, after the Lode has been digged and removed, they call it a Scal or Scale: so if the side of a quarry falls down in large flakes of stone, it is called a Scal, or Scaling.

**SCOVAN—Lode.** Is a Tin Lode, only in contradistinction to all other Lodes.

**SCOVE.** Tin-stuff so rich and pure as it rises out of the Mine, that it has scarce any need of being cleansed by water.

**SCOOP.** See **TEEM**.

**SCROWL.** When a metallick Lode is interrupted and cut off by a Cross-Goffan, it may sometimes be found again by the tendency of some loose stones of the true Lode in the body of the Goffan; i. e. a Scrawl.

**SEAM.** A Seam of Tin is a horse load, viz. two small sacks of black Tin. I believe it is borrowed from the German Mine term, Saume of Quicksilver, about 315 lb in two small barrels on a horse. See **Brown's Travels**.

**SEARGE.** A sieve.

**SERVING.** A Serving, is one or more hand-barrows full of Tin Ore ready for the burning-house or calciner, as it is lodged in the dry or vat for the next serving or supplying the furnace. Called, also, a Layer or Laying of Tin.

**SET.** A Set is the ground granted to a company of Adventurers. The taking of a Set, signifies the having a grant of the ground or Mine. Sometimes it implies the deed or lease by which they enjoy the premises.

**SET—a Price.** To set a price on a share or Dôl in a Mine, is this: when A, who owns a Dôl in a Mine, agrees to give B, another Adventurer in the same Mine,



Mine, a price or sum of money, on condition that B will set a price or value on such or such a Dôl (for instance, one-eighth part) if B accepts the money, he names a price, and so A is at his own option whether he will take B's Dôl at that price, or whether B shall take A's Dôl, and pay him the given price for it. Now this double advantage in favour of A, is in consideration of the earnest-money he gave B; so that let the Dôl be disposed of either way, the earnest-money is out of the question, and belongs to B: on the other hand, A is obliged either to take B's mentioned Dôl, or else to let him have an equal Dôl at the price that B set on it; so that A has his choice of the agreement, and B contents himself with what A refuses or declines.

SHAFT. (Schaft; see Agricola de Re Metallica). A groove or pit. All deep pits on a Mine, or on an Adit, are Shafts, provided they are sunk down from grafs. Of those there is the landing or working Shaft, where they bring up the work or Ore to the surface; but if it be worked by a horse-engine or whym, it is called a Whim-Shaft; and where the water is drawn out of the Mine, it is indifferently named an Engine-Shaft, or the Rod-Shaft.

SHAMMEL. A stage of boards used in old Coffins before Shafts were in common use. So they now call any stage of boards for shovelling of Ore or Deads upon, a Shammel. See COFFIN.

SHED. A shade or shelter from the weather, under which the Cobbers cob the Ore.

SHELF. The loose stones immediately over the fast, or firm rocks. Shelf is distinguished by loose and firm Shelf; those small loose stones that are under the earth, are loose Shelf; those which are larger and not so loose, and just on the fast, or firm rock, are the firm Shelf; and a double Shelf is where there are two such Strata: so that the Miners are often deceived in Shoding, imagining they have but one Shelf to shode upon.

SHODE. Perhaps from the Teutonic, Shuten, to pour forth. Shoding is the method of finding veins of Tin by digging small pits in order to trace out the Lodes of Tin, by the scattering loose stones and fragments that were dispersed from them by the retiring waters of the deluge: those loose stones thus dispersed, are Shode stones.

SHUT—up a work. To discontinue the working a Mine. “A Shut of hard

“ground,” implies a stoep or piece of dense Stratum, that will probably be of short continuance. Shutting or Shooting ground; ground which requires to be blown with gunpowder.

SHUTTING—of Attal. When a Gunnies is filled with Attal or Deads, and they want to have a passage through it, they thrust in deal boards on every side of Durns or frames of timber, whereby they gain a passage through, which they secure with all imaginable speed, as fast as they can clear the Attal. Those boards and Durns in the north of England, they call Groove-timbers and Stop-rods. See DURNS and LATHS.

SIDE-ADIT. When an Adit is partly fallen in or choaked, and it is thought most advisable to drive on the side of the choak, it is called a Side-Adit.

SINK. To sink on the Lode or elsewhere, is to work in depth or deeper from the surface; or to sink a deeper Dippra or Sump in a Mine.

SKIMPINGS. (From Scum or Skimming) In dressing stamp Tin in the kieve or vat, after it is tozed and packed, that is, stirred and settled, the best and heaviest part precipitates to the bottom, and the lightest and poorer part lies uppermost, which is skimmed off and dressed again by itself, by the name of Skimpings Tin.

SKIPSINGS. (ac idem, Stope).

SKIT—Pump, is made like a ship's pump, and draws a little water at a small depth.

SLAB OF TIN. A block of Tin.

SLIDE. A Slide is a Course-Flookan or Course-Goffan, that either inclines faster or in direct opposition to a metallick Lode, which it is wrongly supposed to elevate or depress.

SLIME—Ore, or Slime Tin; the pulverized Mineral mixed with water in the state of Slime or mud; or the superfine particles of Ores which are carried down by the water in stamping or dressing until they settle in a pit of water called the Slime-Pit. In order to recover the Ore in this Slime, they dress it on a frame, whereby they wash off Sludge earth and save the Ore.

SLOCKING-STONE. A tempting, inducing, or rich stone of Ore. Some Miners produce good stones of Ore, which induce the concerned to proceed, until they expend much money perhaps, and at last find the Mine good for nothing: so, likewise, there have been some instances of Miners, who have deceived their employers by bringing them Slocking-Stones



ing-Stones from other Mines, pretending they were found in the Mine they worked in; the meaning of which imposition is obvious.

SLOTTERE. (Cornish) Dirty, slovenly, muddy.

SLOVAN. See LOST-SLOVAN; vulgo Low-Slovan.

SMALL-MEN. Fairies. The Miners are sometimes persuaded, that they hear a pick at work under-ground, as if some invisible spirit was at work underneath or near them. This noise, I suppose, proceeds from the running or falling of waters through the crevices and apertures of the earth. The opinion the Miners have of its being a good omen, encourages them to follow or work to it; so that it has more than once occasioned a lucky discovery.

SMALL ORE. Copper Ore dressed to a small size.

SMALL TIN. Tin dressed from slime, &c. called Smaals. Also Floran Tin.

SOAPY HEADS. The joints of stones, smeared with a saponaceous slippery soil.

SOLE. See BOTTOMS.

SPAL. To spal, is to break large solid rocks of Ore with sledges to a smaller size, in order to cull out the barren stony parts.

SPAL. To spaal. A sconce, amerciament, forfeiture. To deduct so many items or days wages as a person has been wanting from his labour; or else to mulct him more than his wages, according to the usage of that particular Mine.

SPALIARD. A Pickman; a working Tinner. See SPAL.

SPAR. A Misnomer for Quartz and Crystal in Cornwall. Sulphur and pure chalk united from the real substance, Spar.

SPEED. A quick, but wasteful way of dressing, or rather coarse cleansing of Copper Ore, by an iron grate in a quick stream of water.

SPEL. A lift, help, or turn; thus if two men are at any kind of work, and alternately change and relieve one the other, they call it "To give and take a Spel," or Spel and Spel.

SPEND—the Ground. To break and work it away to prove a Mine.

SPILL and WEDGE. Mortices and wedges for locking or fixing large props of timber, which support a Mine, to the walls thereof, that they may hold firm in their places.

SPREADERS. Are pieces of timber that

are placed athwart a Shaft, &c. which is likely to fall in, in order to keep it open and safe, till they can board and secure it.

SQUAT. Woodward calls it a Mineral; but in the Miner's sense of it, "The Squat of the Lode," means a large Lode, or heap of the Lode in one place.

STAMPS—or Stamping-Mill. A mill worked by water for pounding and pulverizing Tin or Copper Ores; having large irons, called Stamp-Heads, fixed to pieces of wood (see LIFTERS) which alternately rise and fall and break the stones.

STAMPS-CAPTAIN. The superintendant dresser at the stamping mill.

STANDING-GROUND. Ground that will stand firm and require no timber and boards to bind and support it.

STANNARY—Laws, Stannaries, and Stannary-Courts; are Laws, Precincts, Customs, and Courts peculiar only to Tinner and Tin Mines.

STANNATORS. The upper house of convocation or parliament of Tinner, twenty-four in number, being chosen by the mayors and corporations of Launceston, Lostwithiel, Truro, and Helstone, for the Stannaries or Precincts of Foymore, Blackmoor, Tywarnhayle, and Penwith and Kirrier. See ASSISTANTS and CONVOCATION.

STEM. A day's work. A double Stem, is to work six hours extra.

STEMMYN. Ditto.

STEMPEL. A slant beam used in Tin Mines. Large pillars or pieces of timber placed in Mines to support them.

STENT. Rubble, loose dead earth.

STILLEN. See ASTYLLEN.

STOPE. A Step. When a sumph or pit is sunk down in a Lode, they break and work it away as it were in stairs or steps, one man following another, and breaking the ground, which manner of working in a sumph or any other part of a Mine, is called Stopeing; and that height or step which each man breaks, is called a Stope. Likewise, hewing away the Lode overhead, is "Stopeing in the back."

STOWS. See AXLETREE.

STRAKE. See STREK.

STREAMERS, STREAMING, and STREAM-WORKS. First, the Tinner which work upon Stream Tin. Second, the Stream-Working. Third, the Stream-Works which are very different from Lode-Works. The first implies Streaming upon the surface, the latter such Works

as



as are wrought in the bowels of the earth.

**STREK.** (A Stream, Cornish) unde Strake. Strakes, are frames made of boards, fixed on or in the ground, where they wash and dress the small Ore in a little stream of water; hence termed Straked Ore.

**STREP.** See STREK.

**STRIK.** (Active, swift; Cornish) To strik or streeck down, or strike down; is to let a man down in a Shaft by the windlass, and if he calls up to the men above-ground to streeck, they let him go farther down; if he says, Hold, they stop; and when he wants to ascend, he cries, Wind up. The phrase of "Striking a Mine idle," is to discontinue the working of her.

**STRING.** A small vein, rib, or branch of a Lode or vein.

**STRUCK-OUT.** When a Lode by any Flookan, or any other accidental interference, is interrupted or cut out, they say also, "She is struck out," or, "She is lost."

**STUL.** (See ASTEL; Stul, a rafter or syle; Cornish). Stil, (Cornish) a house beam.

**SUCKED—Stone.** A honeycombed porous stone.

**SUMPH.** (Sumpff, Agricola) A pit sunk down in the very bottom of the Mine, to cut or prove the Lode still deeper than before; and in order to stoep and dig it away if necessary, and also to drive on the Lode in depth. The Sumph principally serves as a basin or reservoir, to collect the water of a Mine together, that it may be drawn out by an engine or machine.

**SURVEY—**or Outcry for setting of Pitches upon Tribute in a Mine; or ground to sink, stoep, or drive by the fathom, &c. &c.

**SWEEP-RODS.** See FLATS, and POKKERS and JETTERS.

## T

**TACKLE or TAKLE.** (Turn-tree, Derbyshire) The Axle, Rope, Kibbals, &c. appertaining to a Shaft, called "The Running-Tackle."

**TAILS.** The roughest refuse of stamp Tin thrown behind the tail or end of the buddle, which are stamped again with poor Tin-stuff, in order to take out all the Tin remaining in them.

**TAKERS,** are those who take or farm a Mine, or a Pitch upon Tribute in a

Mine of the Adventurers, for any limited time, agreeing to pay them a consideration in money or in kind, after the Tin or Ore is made saleable at the Taker's expence. "To take an end," is to contract for driving the end of an Adit or Drift for so much  $\text{q}^r$  fathom. "To take up an Adventure," is to engage in, or put on, a Mine affair.

**TAMPING A HOLE.** (Stemming a hole, North of England) When a hole is bored in the rock for blasting with gunpowder, they fill the upper part of it, upon the charge of powder, with clay and stony matter rammed down very close and tight, which is Tamping the hole, and the clay and stone is called the Tamping.

**TAPPING.** See CHARGE.

**TEARY-GROUND.** Lode or Stratum that will break and tear up easily, by a multiplicity of sinuses or joints crossing each other. Speedy-Ground.

**TEEM.** (To pour; Swift) To lade out water with bowls or scoops in Stream works, or Dippas under-ground.

**TICKETING.** (See SAMPLE and ASSAYING) The method for sale of Copper Ore, thus: on the appointed day each of the Copper buyers attends and produces a Ticket or written paper, in which is expressed the price that he will give for the Ore; and the best bidder has it.

**TIDE.** Twelve hours. Two Tides, twenty-four hours.

**TIMBERMAN.** See BINDER.

**TIN.** See TIN-STUFF, FLORAN TIN, GRAIN Tin, &c.

**TIN-STUFF.** Tin Ore; the Ore of Tin as it rises out of the earth, is called Tin-stuff, and not Ore, as the Mineral of other Metals is.

**TINNERS.** All Cornish Miners.

**TOAS.** (Paste; Toazer, Armoric, a kneading-trough) unde, to Toaz; that is, to shake or Toss the wet Tin to and fro in a kieve or vat with water, to cleanse and dress it.

**TOL.** (A hole, Cornish) The bounder's part of the Tin-stuff.

**TOLLUR.** (See BOUNDER) A man that inspects or superintends Tin Bounds; because Bounds are described and limited by holes cut in the grassy earth, which must be repeated once every year, which they call Renewing.

**TOMALS.** (Cornish) A quantity, much, great heaps of any thing.

**TOOLS.** All hand implements for working a Mine, such as Picks, Gad, and Shovels.



**TRACE.** To trace the Lode, is the same thing as backing of it; that is, to lay open the Bryle, and discover the back of the Lode, by many pits, for several fathoms in length, east and west.

**TRAIN.** Training the Lode. See **TRACE**. Where a Lode has been discovered for some length upon its back, ut supra, it is called, "The Train of the Lode," and "The Run of the Lode."

**TRELOOBING.** A stirring and working the Loobs or slimy earth of Tin, &c. in a slime-pit, that the mud may partly wash off with the water, and the Ore settle at bottom.

**TRIBUTE.** (A Cope, North of England) A consideration or share of the produce of a Mine either in money or kind, the latter being first made merchantable, and then paid by the Takers or Tributors to the original Adventurers or owners, for the liberty granted to the Takers of enjoying the Mine, or a part thereof, called a Pitch, for a limited time.

**TROIL.** A Tinner's feast or way of merriment, by eating and drinking; called also a Duggle.

**TRUNK.** A Strék or strakes, with a very small stream or dribble of water to wash the slime of Tin or Copper Ore, whereby the lighter earthy parts are carried off with the water. The operation is called, "Trunking the slimes."

**TURN-HOUSE.** When a Drift is driven across the country N. and S. to cut a Lode, they make a right angle from their Drift, and work on the Lode itself, which, as it is in a contrary direction to their past Drift, they call Turning-house, in order to work on the course of the Lode.

**TUT.** Tut-bargain; i. e. by the lump: as when they undertake to perform a piece of work at a fixed price, prove how it may.

**TYE.** The same as Strék, but worked with a smaller stream of water. Tye or Ty, is a word made use of also in the stannary of Blackmore, to signify an Adit or drain.

**TYER—or Tier of Pumps.** A set of pumps belonging to the engine, of which the lower pump or piece is called the Driggoc, but more frequently the Working-piece; the others have names appropriated to them, as the Tye or Adit-lift, the Rose-lift, the Crown-lift, the Lilly, the Puppy, &c. each being a separate Tier or Tyer.

## V

**VAN.** (From the French, Avant, foremost). To make a Van, is to take a handful of the Ore or Tin-stuff, and bruise, wash, and cleanse it on a shovel; then by a peculiar motion of the shovel, to shake and throw forth upon the point of it almost all the Ore that is freed from waste. This operation being repeated, the Ore is collected and reserved, and from thence they form an estimate how many tons of Copper Ore, or how many hundred weight of Block Tin, may be produced out of one hundred sacks of that work or stuff of which the Van is made.

**VATE or VAT.** A square hollow place on the back of a calcining furnace, wherein they lay the next serving of Tin Ore to dry before it is let down into the furnace, into which it passes through a plug hole in the bottom of this Vate or Dry.

**VINNEWED or VINNEY.** (Ainsworth) Mouldy. Vinnewed Ore; Copper Ore that has a blue or green spume, or efflorescence upon it like verdigris.

**UNDERGROUND - CAPTAIN.** See **GRASS-CAPTAIN**.

**UNDERSIZED.** See **DUMB'D**.

**UNHEAD A LODGE.** When a Lode is fractured or interrupted, so as to be entirely intersected by a cross vein, slide, &c. then it is said to be Unheaded.

**VOOGA.** (Cornish) Smoak. We also call a hollow cavern, either in the earth, or the Mines, or by the fretting of the sea, a Vooga; in the Mines, a Vooga-hole.

**VOU-HOLE;** from Vau, or Vauw. A natural cavity, hole, or chasm, in the earth or a Mine; ac id. Vooga. (A Shack, in Derbyshire).

**UPSTANDERS.** Pieces of timber or boards which are fixed in the ground at a Shaft, to support the axletree, &c. See **BRACE**.

## W

**WASTREY.** See **ATTAL**.

**WATER-BARREL.** A large barrel bound with iron hoops, which serves to draw water out of a Mine.

**WATER IN FORK.** See **FORCQUE**.

**WATERMEN.** Those who are any way particularly employed about water underground; especially those who draw water at the Rag and Chain Pump.

**WHEEL.** An abbreviation of Water-wheel, implying a Water-engine.

**WHEEL-PIT.**



**WHEEL-PIT.** A very large but shallow pit that is sunk in the ground, or at some depth under-ground, in order to erect a water-wheel and engine in it.

**WHELE.** Id. Huel, or Wheal. See **HUEL**.

**WHYM or WHIM.** A horse engine. Sometimes its use is to draw water; but mostly it is intended to wind or roll up the work out of a deep Mine, being wrought by horses. An Engine, Derbyshire.

**WHYM-ROUND.** A Volt, (Johnson). Engine-Race, North of England.

**WHYM-SHAFT and WHYM-KIBBAL.** See **SHAFT** and **KIBBAL**.

**WHIP.** See page 179.

**WHITE TIN.** Block Tin, or purified Tin, brought to its ultimate perfection by fire.

**WILD LEAD.** See **MOCK LEAD**.

**WINDLASS.** See **AXLETREE**.

**WINDS.** See **AXLETREE**, **LITTLE-WINDS**. The Turn, North of England.

**WORK.** (From the Teutonic, Werke; a Mine). Work often signifies the Ore or deads, or other earth or stone, that

is broken in a Mine, and brought up to grafs. This word often implies the Mine itself, as when they say, a Rich Work, or a Poor Work, instead of a Rich Mine, or a Poor Mine. A Tin Work. A Copper Work. They likewise term Copper smelting furnaces, Copper Works.

**WORKING-BIG.** Is the space of about two feet and a half wide, so that a man may have room enough under-ground in a Lode or in a Drift to use his Pick and other tools without breaking any of the contiguous Strata not of a veiny nature: hence they say, a Lode is a Working-big, that is, two feet and a half wide.

Z

**Zighyr.** (Slow, Cornish). When a very small flow stream of water issues through a cranny under-ground, it is said to Zighyr or Sigger.

F I N I S.



# TERMS AND IDIOMS OF MINERS

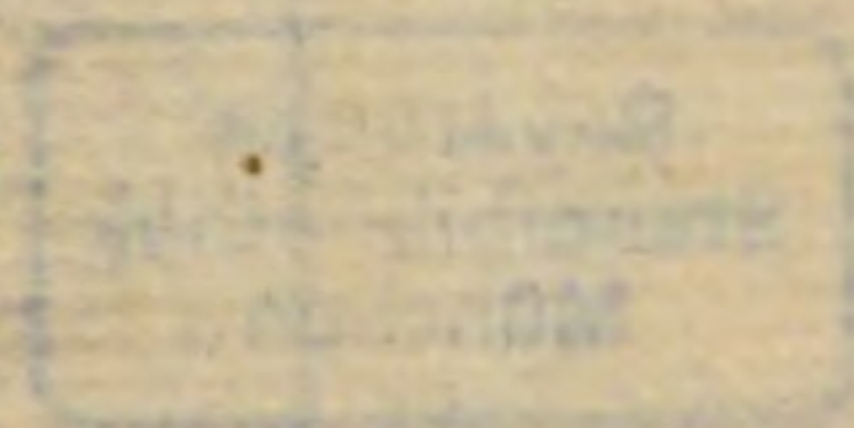
is broken in a mine, and brought up to  
 level. This word often implies the  
 mine itself, as when they say, a Rich  
 Work, or a Poor Work, instead of a  
 Rich Mine, or a Poor Mine. A Tin  
 Work, A Copper Work, &c. &c. like-  
 wise term Copper finding (mines),  
 Copper Work.  
 Working-face, is the face of about  
 two feet and a half wide, to which a man  
 may have room enough under ground  
 in a ledge or in a drift to use his Pick  
 and other tools without breaking any of  
 the coal. Hence they say, a ledge is a  
 Working-face, that is, two feet and a  
 half wide.

## N

Night (Slow Cornish). When a very  
 small flow stream of water issues through  
 a crevice under ground, it is said to  
 Night or Sigh.

Water Pit. A very large but shallow  
 pit, in which the water, or at  
 least a quantity of it, is stored, in order to  
 use it for washing and crushing in it.  
 Water, is said, or Water, see Flute.  
 Water or Water. A hole, or some-  
 times a large one, to draw water; but  
 usually it is intended to wind or roll up  
 the work out of a deep mine, being  
 wrought by horse. An Engine, for  
 driving.  
 Water-Round, A Vole (London). En-  
 gine-Race, North of England.  
 Water-Shaft, and Water-Race. See  
 Shaft and Race.  
 Water. See page 170.  
 Water-Tin, Black Tin, or purified  
 tin, brought to its ultimate position  
 by the  
 Water Lead. See Mock Lead.  
 Waterless. See Axtrease.  
 Water. See Axtrease, latter Water.  
 The Turn, North of England.  
 Work. (From the Teutonick, Werke;  
 a Mine). Work often signifies the Ore  
 or leads, or other earth of stone, that

## F I N I S H













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Pryce, William

Mineralogia Cornubiensis a treatise on Minerals, Mines and Mining

London 1778

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